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TITLE: AN ENERGY-CONSERVATION STUDY FOR THE US AIR FORCE ACADEMY

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SUBMITTED TO To be presented at the US Air Force Academy Energy Management Personnel Meeting, Colorado Springs, Colorado, March 1983.

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AN ENERGY CONSERVATION STUDY

FOR

THE US AIR FORCE ACADEMY

Prepared by

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To be presented at the US Air Force Academy
Energy Management Personnel Meeting
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AN ENERGY CONSERVATION STUDY FOR THE US AIR FORCE ACADEMY*

by

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ABSTRACT

The United States Air Force Academy (AFA) has asked the Los Alamos National Laboratory to assist them in conducting detailed energy and solar analyses of selected AFA buildings using the DOE-2 building energy analysis computer program. This report presents the results of the energy conservation study conducted by Los Alamos in FY 1981 and 1982 for Building 2360 (Vandenberg Hall), Building 2169 (Field House), and Building 2410 (Aeronautics Laboratory).

Energy Conservation and Solar Opportunities (ECOs) are identified for each building and predicted heating, cooling and electric energy savings are presented for each ECO. Economic results are summarized as annual dollars saved, discounted benefit-to-cost ratio, maximum investment targets, and the life-cycle cost of implementing each ECO.

I. INTRODUCTION

The United States Air Force Academy (AFA) at Colorado Springs, Colorado, has for several years been implementing an intensive energy management program for its facilities.

An energy conservation study has been conducted by the Los Alamos National Laboratory for the United States Air Force on three buildings located at the Air Force Academy: Building 2360 (Vandenberg Hall), Building 2169 (Field House), and Building 2410 (Aeronautics Laboratory). The approach included a survey of each building to evaluate the energy use of each by performing a comprehensive energy analysis using the DOE-2 computer program. The intent of this study was to identify energy conservation opportunities (ECOs)

*This work was performed under the auspices of the Department of Engineering/Energy Management, United States Air Force Academy.

that were cost effective in terms of Department of Defense (DOD) economic criteria for Energy Conservation Investment Program (ECIP) projects. The results of this study are presented in a series of recommendations in this report.

II. METHODOLOGY

The energy surveys were based on a detailed review of as-built drawings, on-site verification, and on-site discussions with building managers and operating personnel. Data were collected regarding the number of people occupying the buildings, operating schedules, and the energy loads imposed by equipment and lights. Heating, ventilating, and air-conditioning (HVAC) and physical plant equipment and operating practices were also investigated.

Input for the DOE-2.1A computer model of these buildings was based on the results of these surveys. Preliminary ECOs were developed, computer simulations were performed, and the results for each ECO were compared against those obtained from a simulation of the existing building (base line energy consumption). Those ECOs showing the greatest performance improvement at the least potential cost were subjected to a final computer analysis evaluating the effect of combining promising ECOs. The energy savings reported within the Recommendations, Sec. IV, reflect the incremental energy saved when combining alternative ECOs.

The basis for funding requests by the Air Force Academy for each ECO was established by the ECIP criteria that

1. all projects amortize within their economic life, and
2. all projects produce an energy-to-cost ratio (E/C) of at least 15.

In our judgment, the cost of implementing each recommended ECO will be less than the funds requested. Appendix A presents a detailed discussion of the performance analysis of each building; a detailed economic analysis can be found in Appendix B.

III. BUILDING DESCRIPTIONS

Vandenberg Hall is a 760,000 ft^2 complex billeting 2,400 Air Force cadets and providing laundry, storage, recreational, assembly, and shopping facilities to the residents. The building is characterized by energy conserving architectural features such as insulated curtain walls, 10-in. concrete floors and roofs with exterior insulation, and heat-absorbing, double-glazed, operable windows. Like many other buildings of the Academy, Vandenberg Hall is supplied with hot water from a central boiler utility through an underground tunnel distribution system. The high-temperature water from the utility is converted within the building to medium- and low-temperature sources of water serving the HVAC and domestic hot water (DHW) systems, respectively. With the exception of certain specialty areas within the building, air temperatures are maintained at 65°F during the day and 55°F at night in the winter by hot water baseboard heaters. In the summer, the tempering effect of manually operated drapes and windows couple with the massive concrete structure to passively control the temperature swings within the living quarters. A once-through ventilation system is used to maintain air quality within the building throughout the year.

The Field House is a two-story 246,000 ft^2 high-bay building that encloses a basketball stadium, an ice hockey arena, and a multipurpose/track facility. Like Vandenberg Hall, this building is supplied with hot water from a central boiler utility and underground tunnel distribution system to heat the building. Mechanical chilling is provided to produce ice for the ice hockey rink. The building is serviced by several large air-handling units in each of the above three areas. These units function in a 100% recirculation mode to maintain the building at 68°F. During sports events, concerts, or other activities in which there are a large number of people in the building, the units operate in a 100% ventilation mode in which outside air is brought into the building to meet the increased interior load. Space cooling is accomplished entirely through the use of mechanical ventilation.

The Aeronautics Laboratory (Aero Lab) is a two-story building functionally divided into classrooms, laboratories, offices, and test cells. The building is an architecturally massive structure with an advantageous solar orientation along a long east-west axis. However, the building has limited potential as a solar heating retrofit project because of the large internal loads generated within the structure. The flat roof is constructed of built-up roofing on a 2-in. poured gypsum foundation. The exterior walls on the upper floor are precast concrete panels covering a cinder block structure whereas the lower floor walls are a combination of concrete block and poured concrete with the north and west walls completely underground. The Aero Lab receives high-temperature hot water from the central boiler utility and converts the water to medium-temperature water for use in the building HVAC system. Chilled water for space cooling is received from absorption chillers located in the basement of Fairchild Hall, which is adjacent to the Aero Lab. A central multizone system serves the entire upper floor area and most of the lower floor. With the exception of the mechanical room and the test cells, air temperature is maintained at 68°F during the day and 60°F at night. A four-pipe fan coil system is used to heat and cool the test-cell classrooms. Unit heaters are used to heat those areas not conditioned by the multizone or four-pipe fan coil systems; a thermostatically controlled ventilation fan cools the mechanical room.

IV. RECOMMENDATIONS

A. Building 2360, Vandenberg Hall

There are four recommendations for Vandenberg Hall that meet the FY-1984 ECIP guidance for cost effectiveness: ventilation air reductions, heat recovery, motor and fan efficiency improvements, and reinstatement of economizer operation. Each is described below and the existing equipment that will be affected by these recommendations is identified.

1. Reduce Building Ventilation Rates. Vandenberg Hall was designed in 1956 to meet all building codes in effect at that time; however, since 1956, a significant amount of research has been conducted to determine the effect of ventilation air on the health of building occupants. This research has led to the lowering of minimum fresh air requirements for buildings in keeping with more energy efficient design practice. The American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) summarizes the recommendations of their Society concerning the results of this research in the nationally accepted ASHRAE Standard 62-73, "Standards for Natural and Mechanical Ventilation." It is proposed that the operation of the ventilation equipment supporting Vandenberg Hall be modified in accordance with this standard. The ventilation equipment that would be affected by this modification includes the heating and ventilating units supplying fresh air to the building corridors (corridor fans) and the fans (toilet and storage area fans) exhausting air from the shower, toilet, and storage areas of the building. The equipment numbers are shown in Tables I and II under the heading, "Supporting Ventilation Equipment."

ASHRAE Standard 62-73 recommends that a minimum of 10 cfm and 15 cfm of fresh air be supplied to each person occupying the shower and toilet areas of a military installation, respectively. Assuming that all of the occupants of the cadet facilities be located in these areas at any one time, the minimum ventilation rate can be calculated as follows:

$$2400 \text{ people} \times \frac{(10 + 15)}{2} \text{ cfm/person} = 30{,}000 \text{ cfm.}$$

The corridor fans are installed to deliver 56,000 cfm of fresh air to these areas continuously, as well as 32,900 cfm to the storage areas of the building through use of the building corridors as supply air plenums. Toilet fans are installed to exhaust 56,000 cfm of air from the shower and toilet areas continuously. We recommend that delivery of 88,900 cfm through these corridors be reduced and that the air exhausted from the shower and toilet areas be reduced to 30,000 cfm. The exhaust air reduction should be accomplished, as indicated in Table I, to maintain the building air balance. Reducing the air exhausted from each individual shower and toilet area in proportion to the total recommended reduction will provide the ventilation rates shown in Table I.

Reductions in ventilation air continuously supplied to the storage areas of Vandenberg Hall are also recommended. ASHRAE Standard 62-73 recommends a minimum ventilation rate of 5 cfm per person in storage areas. Assuming that only one person occupies every 200 ft^2 of storage floor area during duty hours, the rate of fresh air recommended for each storage area is shown in Table II. The storage fans supporting these areas should exhaust air at the rates indicated in Table II. Note that the recommended ventilation rate of 1,252 cfm for all of these areas is considerably less than the 32,900 cfm currently exhausted. Because the supply of fresh air to the storage areas is also provided by the corridor fans, a total reduction from the 88,900 cfm currently supplied to 31,252 cfm is recommended to maintain the building air balance.

Other areas of Vandenberg Hall were investigated for potential reductions in the rate of fresh air delivery. The truck dock, fireplace, lyceum, forge, and paint spray booth are ventilated by fans that are infrequently used, so they were excluded as potential candidates. Likewise, the electrical

TABLE I

SHOWER AND TOILET VENTILATION RECOMMENDATIONS

Building Location	Design Ventilation Air (cfm)	Recommended Ventilation Air (cfm)	Supporting[a] Ventilation Equipment
First Floor, Unit 3	1,560	836	HV 3 and 4; EX-19
Second Floor, Unit 1	5,880	3,150	HV 42, 43, 54, 55; EX-1 thru 4, 6 and 7, 9 thru 16
Second Floor, Unit 2	3,920	2,100	
Second Floor, Unit 3	3,740	2,004	
Third Floor, Unit 1	5,880	3,150	
Third Floor, Unit 2	3,920	2,100	
Third Floor, Unit 3	3,740	2,004	
Fifth Floor, Unit 1	5,860	3,139	HV 44, thru 53 EX-1 thru 4, 6 and 7, 9 thru 16
Fifth Floor, Unit 2	3,900	2,089	
Fifth Floor, Unit 3	3,920	2,100	
Sixth Floor, Unit 1	5,860	3,139	
Sixth Floor, Unit 2	3,900	2,089	
Sixth Floor, Unit 3	3,920	2,100	
Total	56,000	30,000	

[a]Refer to equipment numbers on building drawings.

TABLE II

STORAGE VENTILATION RECOMMENDATIONS

Building Location	Floor Area (ft^2)	Recommended Ventilation Air (cfm)	Supporting[a] Ventilation Equipment
First Floor, Unit 3	17,064	427	HV 3, 4; EX-19
Second Floor, Unit 1	6,440	161	HV 42, 43, 54, 55; EX-20
Second Floor, Unit 2	5,840	146	HV 42, 43, 54, 55; EX-21
Second Floor, Unit 3	7,200	180	HV 42, 43 54, 55; EX-22
Third Floor, Unit 1	6,440	161	HV 42, 43, 54, 55; EX-20
Third Floor, Unit 2	5,840	146	HV 42, 43, 54, 55; EX-21
Third Floor, Unit 3	1,232	31	HV 42, 43, 54, 55; EX-22
Total	50,056	1,252	

[a]Refer to equipment numbers on building drawings.

substation and utility tunnel areas are unconditioned spaces, so modifications to the fans ventilating these areas would not realize significant energy savings. All of the remaining areas require only 19,560 cfm of fresh air delivery by other ventilating fans, so they were dismissed as marginal candidates.

The implementation of this recommendation is calculated with DOE-2.1A to save 13,287 x 10^6 Btu of primary energy annually at the source.

2. Waste Heat Recovery. The potential for reclaiming waste heat currently exhausted to the environment is large for Vandenberg Hall. Conservatively assuming that Recommendation 1 is adopted, even after significant

reductions in ventilation air rates, some 50,812 ft^3 of heated air will be exhausted each minute from this building. This equates to a consumption of

$$1.08 \times \frac{50{,}812\ \text{cfm}}{1.3 \times 0.7} \times 8023^{\circ}\text{F-day} \times \frac{24\ \text{h}}{\text{day}} = 11{,}612 \times 10^{6*}\ \text{Btu}$$

of fuel annually at the central boiler plant. Thus, we recommend that either one of two approaches or a combination of both approaches be used to reclaim waste heat: waste heat recovery from the ventilation air exhaust, and/or heat recovery from the utility tunnel system.

The recovery of heat from air exhausted from the building can be accomplished by constructing a closed run-around heat recovery loop with heat exchange coils located in the supply and return ventilation system ductwork. Heat recovered from the exhaust air would be used to preheat the building's outside air supply. We proposed such a system for the Sigma Building at Los Alamos National Laboratory and a copy of the conceptual scheme is shown in Fig. 1. The equipment affected would be the same as shown in Table I and Table II plus fans HV-1, 2, 6, 7, 8, and EX-5, 8, 17, 26, 32, 33, and 24.

The second heat recovery option would involve reclaiming waste heat from the utility tunnels serving the Air Force Academy. We estimate that 300 Btu/h of heat can be recovered for each linear foot of utility tunnel. This assumes that two (supply and return) 6-in.-diam pipes with 1 1/2-in. of insulation transmit 350°F water through the tunnels. Thus, it would require nearly 3100 linear feet of tunnel to offset the ventilation heat losses of this building. This is determined as follows:

$$\left(11{,}612 \times 10^{6}\ \frac{\text{Btu}}{\text{yr}} \times 0.7\right) / \left(\frac{300\ \text{Btu}}{\text{h-ft}} \times 8760\ \frac{\text{h}}{\text{yr}}\right) = 3093\ \text{linear feet.}$$

*In the above calculation, the combined boiler plant and hot water distribution system is assumed to be 70% efficient and the factor 1.3 is used to convert the ventilation rate at 7100 ft elevation to standard air rates at sea level. The degree days shown are for a 70°F base temperature at Colorado Springs, Colorado. The temperature of the air supplied by the ventilation equipment is 70°F.

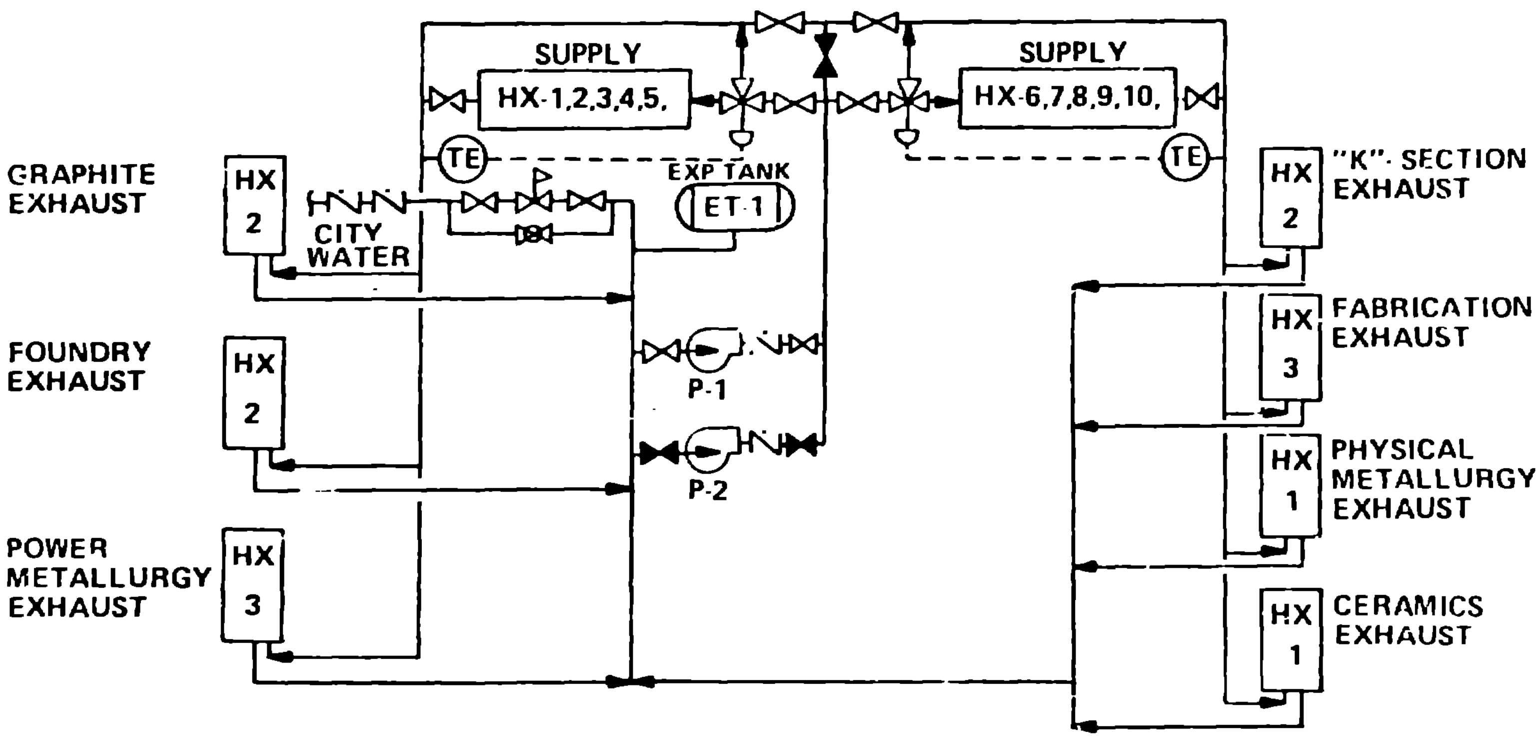

Fig. 1. Heat recovery system for Sigma Building at Los Alamos National Laboratory.

New fans, filters, and distribution ductwork inducing utility tunnel air will have to be installed to deliver the reclaimed waste heat to the ventilation system. The ventilation equipment affected by this modification is the same as specified for the first option for heat recovery.

We suspect that a combination of both heat recovery options will yield the most cost-effective solution. In any event, DOE-2.1A calculations indicate the saving of primary energy (at the source) at 9,477 x 10^6 Btu annually. This assumes option 1 is implemented with a heat recovery effectiveness of 75%.

3. Motor and Fan Efficiency Improvements. Many of the fans in Vandenberg are extremely inefficient. For example, the corridor fans HV 45, 49, 50, 52, and 53 are calculated to be 18% efficient as follows:

$$\text{Fan efficiency} = \frac{5800 \text{ cfm} \times 0.5 \text{ in. } H_2O}{1.3 \times 6356 \ \frac{\text{cfm-in.}}{\text{hp}} \times 2.0 \text{ hp}} = 18\%$$

The fan efficiencies of corridor fans range from 18 to 26% and the exhaust fans efficiencies range from 20 to 32%. Furthermore, none of the fans supporting the cadet assembly areas (assembly fans) exceed 18% efficiency. Because corridor, toilet, and storage fans run continuously, a significant opportunity exists to reduce fan power consumption. The assembly fans present a similar, although somewhat reduced, opportunity because they must operate continuously during the winter to maintain thermal comfort and to prevent freezing in the assembly rooms. We recommend that the fans and fan motors supporting these areas be replaced with new fans and motors. The equipment to be replaced should include the assembly fans HV 10 through 39 as well as the equipment defined as being affected by Recommendation 2. Assuming that Recommendations 1 and 2 are implemented and that the specified fan/motor efficiencies can be doubled, DOE-2.1A calculations show the primary energy (at the utility) saving at 4,711 x 10^6 Btu annually. Larger savings can be realized by fan/motor replacement if the ventilation air reductions recommended previously are not implemented.

4. Reinstatement of Economizer Operation. Maintenance personnel, in the interest of saving energy, have programmed the fresh air dampers of multizone fans S-41 and EX-35 closed when the outdoor temperature drops below 60°F. This is an inappropriate modification of the system that conditions the cadet store area in Vandenberg Hall. The cadet store area is characteristic of a

space that has large internal energy sources. This space requires only a nominal amount of heat, but must be cooled year-round. By programming the fresh air dampers to close when the outdoor temperature drops below 60°F, the system is incapable of providing free ventilation cooling during the winter. All of the cooling must be accomplished by expensive mechanical cooling. We recommend that the economizer cycle originally programmed be reinstated to provide ventilative cooling.

The implementation of this recommendation is calculated by DOE-2.1A to save 350 x 10^6 Btu annually at the (electric utility) source, assuming that Recommendations 1, 2, and 3 have been previously adopted.

B. Building 2169, Field House

There is only one recommendation for the Field House that meets the FY 1984 ECIP guidance for funding: the pressurization of the building to offset infiltration losses.

An infiltration rate of 0.58* air changes/h is estimated for the Field House. This equates to an infiltration rate of 109,166 cfm for a building volume of 11,293,128 ft^3. If the building could be pressurized with 66,000 cfm of 70°F air drawn through the adjacent high-temperature (350°F) hot water utility tunnel such that 60% of the infiltration was eliminated, the consumption of

$$1.08 \times \frac{66{,}000\ \text{cfm}}{1.3 \times 0.7} \times 8023^\circ\text{F-day} \times \frac{24\ \text{h}}{\text{day}} = 15{,}083 \times 10^6\ \text{Btu}$$

of fuel annually at the central boiler plant could be avoided. Thus, we recommend that waste heat recovery from the utility tunnel system be implemented.

The recovery of 10,558 x 10^6 Btu (that is, 15,083 x 10^6 x 0.7) of waste heat from the utility tunnel distribution system would require approximately 4000 linear feet of tunnel. This assumes a 350°F water temperature, two 6-in.-diam pipes per utility tunnel, 1-1/2 in. of insulation on the pipes and a maximum of 7.5 mph of air flowing through tunnels. Subsequent to this study, the Air Force Academy completed a retrofit project to install an additional 2 in. of fiber glass insulation on the hot water utility pipes within

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*The estimate of infiltration was made after discussions with Joseph Ashley of the US Naval Civil Engineering Research Laboratory. He has been under contract (MIPRN-81-6 with Tyndall AFB) to perform tracer gas infiltration tests of large airplane hangers.

the tunnel adjacent to the Field House. The reduced heat loss available for recovery increases the length of tunnel required to 13,400 linear feet.

The recommended ECO retrofit involves the installation of heat recovery equipment including fans, ductwork, and necessary equipment to allow the existing air-handling equipment in each of the three large areas of the building to distribute this preheated air. A table of the major air-handling equipment in each area is provided in Table III.

TABLE III

MAJOR AIR-HANDLING EQUIPMENT

Building Zone	Floor Area (ft^2)	Volume (ft^3)	Major Supporting Ventilation Equipment
Basketball Stadium	47,124	2,780,316	AH-1 through AH-8, AH-10 AH-36, EF-1 through EF-5
Ice Hockey Arena	47,124	2,780,316	AH-11 through AH-18 EF-6 through EF-9
Multipurpose/Track	74,579	5,667,980	AH-20 through AH-31 EF-10 through EF-13

DOE-2.1A calculations show the saving of primary energy (at the source) at 10,543 x 10^6 Btu annually, assuming that the space is maintained at the current setting of 68°F. A no-cost option of lowering this setpoint to 65°F would reduce this savings slightly.

C. Building 2410, Aeronautics Laboratory

There are three recommendations for the Aero Lab that meet the FY-1984 ECIP guidance for cost effectiveness: seasonal heating and cooling, revised control of the central multizone system, and evaporative cooling. Each is described below.

1. Seasonal Heating and Cooling. The heating and cooling systems for this building were designed to be available on an annual basis. However, DOE-2.1A simulations show that heating and cooling need only be provided seasonally and never simultaneously. We recommend that the heating system be shut down and that cooling be provided only during the summer.

This could be accomplished by turning on or off the hot water pumps P-1 and P-2 with a signal from an instrument sensing outdoor temperature. The same signal could be used to prohibit or permit the delivery of chilled water from Fairchild Hall.

DOE-2.1A calculations show the saving of 302 x 10^6 Btu of primary energy annually for the implementation of this strategy.

2. Demand Control. The central multizone system S1 maintains comfort in supported zones of the building by automatically modulating the mix of hot and cold air supplied through damper activity. Hot air is supplied at 100°F and mixed with cold air at 64°F. Revising the control of such systems to adjust the temperature of hot and cold deck coils usually results in substantial energy savings. The temperature adjustment is done by a comparing the demand for cooling or heating in each of the zones of the system. The temperature of the hot deck is adjusted to just meet the requirements of the coldest zone and the cold deck is adjusted to meet the requirements of the warmest zone. We recommend that a comparitor microprocessor be installed to perform this control.

Implementation would require the installation of a comparitor microprocessor and two linear thermostats. Signals from the room thermostats are already transmitted to the Mechanical Room for use in modulating zone dampers. Fig. 2 shows a possible interface with existing controls.

DOE-2.1A calculations show a saving of 272 x 10^6 Btu of primary energy annually. This assumes that Option 1 above has been previously implemented.

3. Evaporative Cooling. This opportunity involves the installation of an evaporative cooler in the Subsonic Wind Tunnel Room, and the addition of an air washer to the central multizone system S1. This opportunity presumes that the Subsonic Wind Tunnel room will no longer be served by system S1 because system S1 does not have sufficient capacity to condition this space. An independently controlled and evaporatively cooled ventilation unit is recommended to maintain the comfort conditions in this space. Currently, classroom experiments must be turned off occasionally because of a severe overheating problem.

The implementation of this scheme will realize primary energy savings (calculated by DOE-2.1A) of 785 x 10^6 Btu annually, assuming that Options 1 and 2 above have been previously implemented. We recommend installation of both a 35,000 cfm evaporative cooler and an airwash spray system for the central multizone system S1.

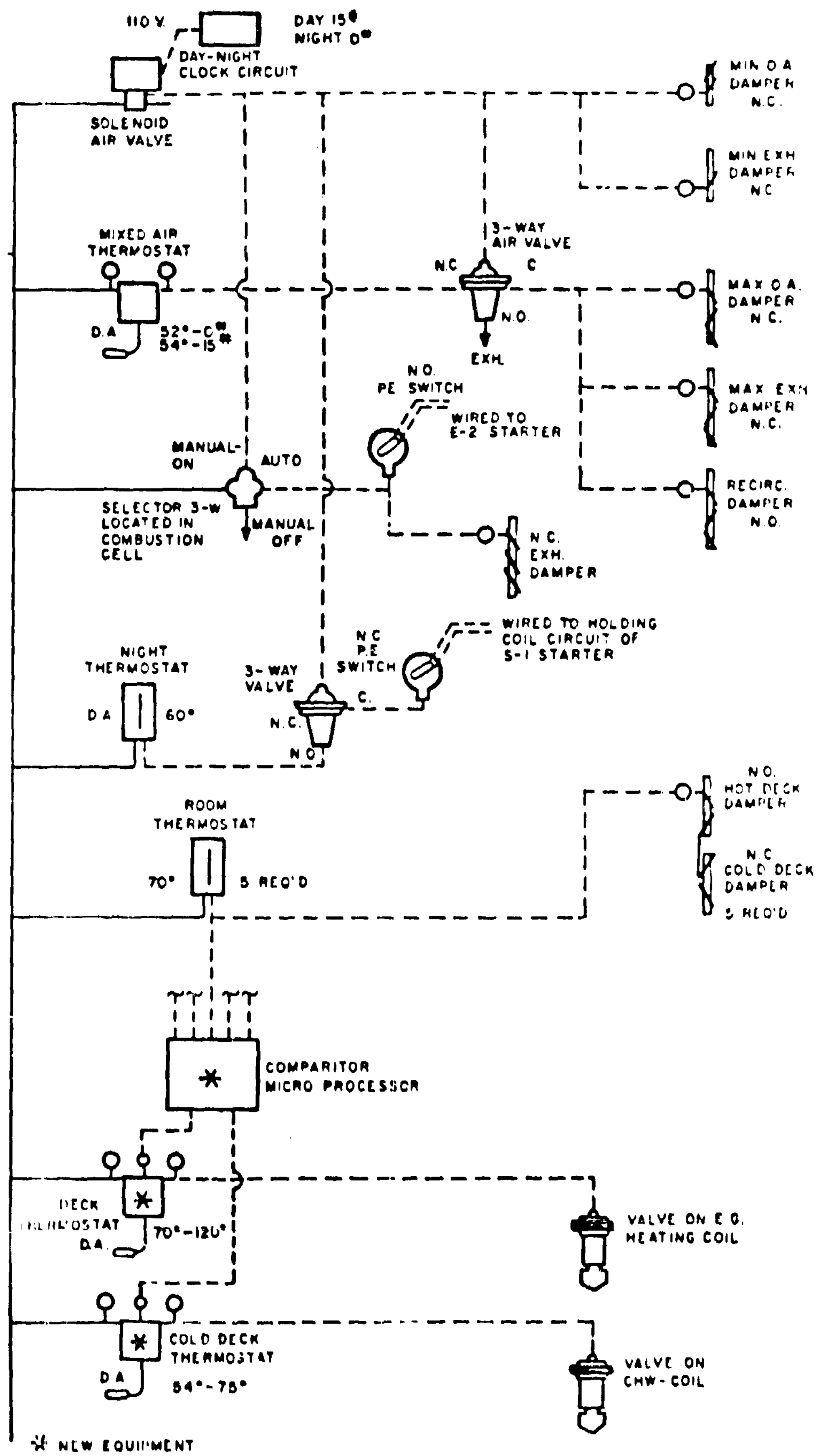

Fig. 2. Suggested revised controls for multizone system S1.

V. CONCLUSIONS

A summary of the recommended ECIP projects (including absolute and relative annual energy and cost savings, savings per invested dollar, discounted benefit/cost ratio, and life-cycle cost) is provided in Table IV for the three buildings studied. The funds (programmed amount) requested for the implementation of the recommendations of this study are $1,947,700 for Vandenberg Hall to save 27,825 x 10^6 Btu's; $795,214 for the Field House to save 10,543 x 10^6 Btu's; and $102,504 for the Aero Lab to save 1,359 x 10^6 Btu's. These investments are life-cycle cost effective in accordance with established Department of Defense ECIP economic criteria. Although no solar projects are recommended, we have determined the energy and cost savings associated with the implementation of solar domestic hot water heating systems for all three buildings and a number of solar space heating options for the Aeronautics Laboratory (see Appendixes A and B). None of these solar projects are deemed cost effective at current fuel prices.

No attempt was made to rank these recommendations as to their cost effectiveness; ranking will be accomplished after a cost estimate of each recommendation has been prepared by the Air Force Academy. In our judgment, the cost of implementing each recommended ECO will be less than the programmed amounts requested.

TABLE IV

SUMMARY OF RECOMMENDED ECIP PROJECTS

Option	Estimated Energy Use (Btu/ft²/yr)	% Energy Reduction	Estimated Annual Savings $1,000	Estimated Annual Savings 10^6 Btu	10^5 Btu Saved per $1000 Invested	Maximum Investment ($)	Discounted Benefit/Cost Ratio	Life-Cycle Cost ($1,000)
I. Vandenberg Hall, baseline	120,834	--	--	--	--	--	--	--
1. Minimize ventilation rates	103,350	15	160	13,287	15.0	1,001,360	3.413	-2,417
2. Run-around heat recovery combined with option 2	90,887	25	274	22,764	15.0	1,715,586	3.398	-4,114
3. Improve fan/motor efficiencies combined with options 2 and 3	84,681	30	284	27,475	16.0	1,935,966	3.125	-4,114
4. Reinstate economizer combined with options 2, 3, and 4	84,217	30	284	27,825	16.1	1,947,720	3.114	-4,117
II. Field House, baseline	188,281	--	--	--	--	--	--	--
1. Utility tunnel heat recovery	145,432	23	130	10,543	15.0	795,214	3.479	-1,971,126
III. Aeronautics Laboratory, adjusted baseline	462,846	--	--	--	--	--	--	--
1. Seasonal heating and cooling	450,826	3	3	302	15.0	22,778	2.059	-24
2. Demand control combined with option 2	440,000	5	7	574	15.0	43,294	2.169	-51
3. Evaporative cooling combined with option 3	408,756	12	15	1,359	15.0	102,504	3.162	-222

APPENDIX A

PERFORMANCE CALCULATIONS

I. BUILDING ENERGY ANALYSIS COMPUTER PROGRAM

The source program for this energy study is the Department of Energy's DOE-2 computer program for energy analysis of buildings. The particular version of DOE-2 used in this study is DOE-2.1A with modifications to incorporate a special subroutine that permits the SYSTEMS program to model spray coils, and another special subroutine that permits modeling of Trombe walls. This modified version of DOE-2.1A is operated through the Los Alamos National Laboratory's Central Computing Facility.

The computer program calculates the hour-by-hour energy use of the building, given information of the building's location, construction, operation, HVAC equipment, and primary energy conversion equipment. The program has four main computational sections: LOADS, SYSTEMS, PLANT, and ECONOMICS. The first three of these sections were used in this analysis. The economics were calculated separately using Air Force economic parameters. These computational sections are identified below, together with the major elements of the building system that must be addressed in the energy study.

1. LOADS: building envelope (exposed surfaces; that is, exterior walls, roofs, slab floors, windows), and internal loads (people, lights, equipment, and infiltration).
2. SYSTEMS: HVAC systems (ventilation loads, fan electrical loads, heating, and cooling loads).
3. PLANT: building central plant (heating and cooling equipment plus related equipment loads; total energy use with breakdown by energy category).

For all runs the Test Reference Year (TRY) weather tape for Denver, Colorado, was used instead of that for Colorado Springs because the latter was found to be incorrectly packed by the Control Data Corporation.

II. SPECIFICS CONCERNING INPUT DATA

A. Vandenberg Hall

1. LOADS input. The building was divided into seven zones based on the as-built drawing furnished by the Air Force Academy. Figure A-1 is an isometric view of Vandenberg Hall created by our DOE-2.1A version. Table A-I

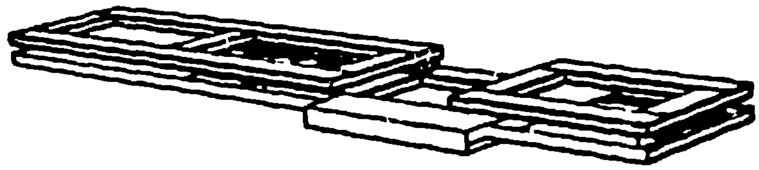

Fig. A-1. Isometric view of Vandenberg Hall.

TABLE A-I

LOADS ZONING

Space Name	Location of Space	Areas Simulated
56W	Units 1 and 2 of 5th and 6th floor	438 cadet rooms, toilets, laundry, corridor, storage, orderly room.
56E	Unit 3 of 5th and 6th floor	220 cadet rooms, toilets, laundry, corridor.
23W	Units 1 and 2 of 2nd and 3rd floor	436 cadet rooms, toilets, laundry, corridor, orderly room.
23E	Unit 3 of 2nd and 3rd floor	220 cadet rooms, toilets, laundry, corridor, orderly room, test cell.
23S	1st through 3rd floor	Mail, shops, storage, truck dock, cadet store, custodian, display, offices, supply, lobby.
23N	1st through 3rd floor	Model engineering display, radio club, chess, printing and finishing studio, reading, assembly, chaplian, conference, magazines, lyceum, hobby shop.
4	4th floor	Assembly, security flight, and IEO administration.

shows the assignment of space names to physical areas within the building and Fig. A-2 exhibits the architectural plan and elevation views of the building. The basement, which includes six mechanical rooms, piping tunnels, and electrical unit substations, was not simulated because it is not conditioned.

A series of LOADS sensitivity studies was completed to establish the energy problem in the building. The building was simulated as it is currently operated; it was then compared to LOADS simulations with different infiltration rates varying from 0.79 air changes/h to 1.85 air changes/h. The LOADS output for each run showed infiltration to be the largest component of the building load; consequently, a significant effort was made to calculate accurately the infiltration rates of the building. The ASHRAE crack length was used to estimate the infiltrate rate; different rates were calculated for each space simulated. These rates, when multiplied by the volume of the associated space, summed, and divided by the total building volume, yield an infiltration rate of 0.85 air changes/h for the entire building. This rate was applied to the base case building.

2. SYSTEMS input. The air distribution systems that support Vandenberg Hall are principally once-through air-handling systems that support the cadet living quarters. However, the assembly areas are supported by heating and ventilation (H and V) units that recirculate air within the space and the cadet store area is served by a multizone unit that also recirculates conditioned air. The three HVAC systems shown in Tables A-II through A-IV were input to simulate the distinct operational characteristics of the air distribution systems described above.

The CENTRAL system models the once-through ventilation system that supplies 70°F air to the cadet living quarters. The fans of this systems run 24 hours a day, 7 days a week. Baseboard heaters provide enough heat to maintain a 65°F daytime and 55°F nighttime temperature in the conditioned space. The baseboard thermal output is reset based on the outside air temperature.

The assembly areas served by the ASSEMBLY system were previously heated by a radiant floor panel system that has since been rendered inoperative. Consequently, the recirculating H and V units must now provide all of the heating. The spaces served are heated to 65°F during the day and 55°F at night. The fans are run continuously during the winter but are turned off in the summer. Demand control varies the temperature of air delivered to the

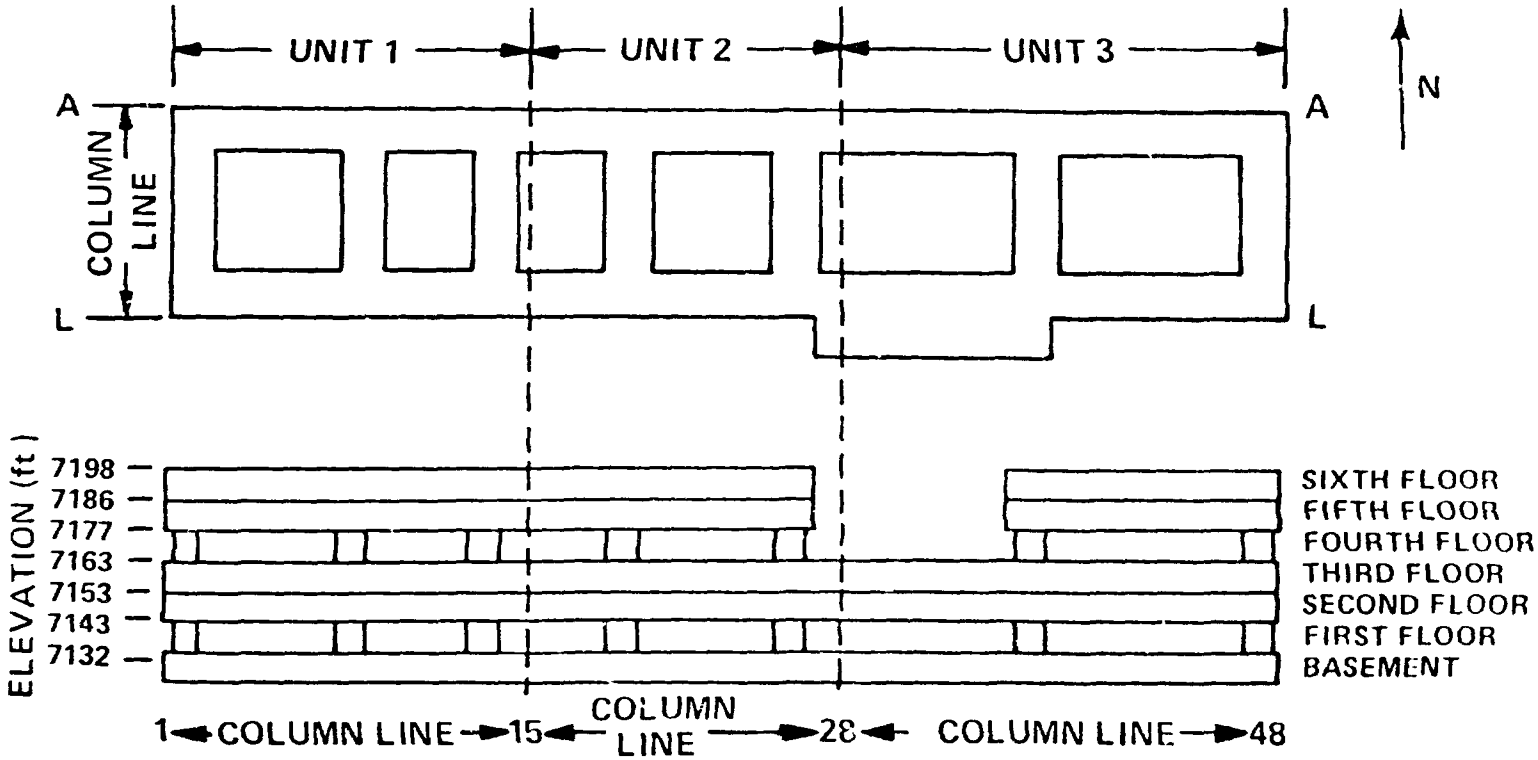

Fig. A-2. Architectural plan and elevation views of Vandenberg Hall.

TABLE A-II

ZONES SERVED BY CENTRAL HVAC SYSTEM

Zones	Area Served	Ventilation Rate (cfm)	Supporting Ventilation Equipment
23W	Toilets	19,600	HV-42, 43, 54, 55; EX-1 through 4, 6, and 7; EX-9 through 16.
	Storage	8,800	HV-42, 43, 54, 55; EX-20 and 21.
	Orderly	960	HV-1 and 2; EX-5 and 8.
23E	Toilets	7,480	HV-42, 43, 54, 55; EX-1 through 4, 6, and 7; EX-9 through 16.
	Storage	9,600	HV-42, 43, 54, 55; EX-22.
	Mechanical	10,400	HV-42, 43, 54, 55; EX-17.
	Test Cell	100	HV-42, 43, 54, 55; EX-40.
23N	Toilets	1,560	HV-3 and 4; EX-19.
	Storage	14,500	HV-3 and 4; EX-19.
	Hobby Shop	5,000	HV-8; EX-27, 32 and 34.
	Radio Listening	500	HV-7; EX-26.
	Dark Rooms	2,600	HV-6; EX-33.
56W	Toilets	19,520	HV-44 through 53; EX-1 through 4, 6, and 7; EX-9 through 16.
56E	Toilets	7,840	HV-44 through 53; EX-1 through 4, 6, and 7; EX-9 through 16.

TABLE A-III

ZONES SERVED BY ASSEMBLY HVAC SYSTEM

Zones	Area Served	Air Handling Capacity (cfm)	Supporting Air-Handling Equipment
4	Assembly	75,600	HV-10 through 39.
	Security Flight	4,500	HV-40 through 41; EX-50.
	IEO Administration	600	HV-56; EX-51.

TABLE A-IV

ZONES SERVED BY STORES HVAC SYSTEM

Zones	Area Served	Air Handling Capacity (cfm)	Supporting Air-Handling Equipment
23S	General Supply	27,430	S-41; EX-35.

spaces from 55 to 120°F. An economizer cycle has been overridden by a field modification that permits the introduction of fresh air into the conditioned spaces only when the outdoor temperature rises above 60°F.

The STORES system models a 100% recirculation multizone air distribution system with direct expansion (DX) cooling. The conditioned spaces are controlled between 65 and 80°F all year round; the fans run 24 hours a day, 7 days a week. During the winter, an economizer cycle is overridden to permit the introduction of fresh air into the conditioned spaces only when the outdoor temperature rises above 60°F. During the summer (June, July, and August), a spray coil is activated to provide evaporative cooling, thus displacing mechanical chilling. Because DOE-2.1A is incapable of modeling evaporative cooling in conjunction with DX cooling, no ECO energy savings are reported for this system during the summer months.

The systems modeled do not include all of the air-handling systems in the building; those units supporting the lyceum, truck dock, and fireplace are infrequently used so they were not simulated. Furthermore, the fans for the unit substations, tunnels, and some toilet exhaust fans on the first floor were ignored because the spaces they served were unconditioned.

3. PLANT input. The high-temperature water supplied to the medium- and low-temperature water systems of Vandenberg Hall was simulated by the steam utility option of the DOE-2.1A program. Energy consumed at the source was calculated by hand by taking the DOE-2.1A results for steam consumption and dividing by an overall generation and distribution efficiency of 70%.

The entire cooling load for the building was met by a packaged multizone system for the STORES system. A dummy centrifugal chiller was specified in PLANT to keep the program from aborting.

B. Field House

1. LOADS input. The Field House was divided into three distinct areas based on thermal characteristics and usage. These three zones are (1) the basketball stadium, (2) the ice hockey arena, and (3) the multipurpose/track facility. Data used in the LOADS input were taken from an energy survey performed on the Field House that included a detailed review of the as-built drawings, a site survey, discussion of the building's operation and performance with the facility's personnel, and information on occupancy and lighting loads.

Figure A-3 is an isometric view of the Field House generated by the DOE-2.1A program. Figure A-4 shows the plan view of the building and the assignment of zone/space names to the physical areas within the building.

The results of the LOADS run show infiltration to be the largest component of the building load for all three zones, lighting to be the second largest component, and heat loss through the roof to be the third largest component.

2. SYSTEMS input. The Field House is served by several large air-handling units in each of the zones. These units normally function in a 100% recirculation mode to maintain the building at an average temperature of 68°F. During sports events, concerts, or other activities in which there would be a large number of people in the building, the units operate in a 100% ventilation mode in which outside air is brought into the building to meet the increased internal load.

The fans and heating coils in each of the three zones operate on an as needed basis to maintain the thermostat set point in each zone. The temperature of the air provided to the zone is modulated between 120 and 60°F

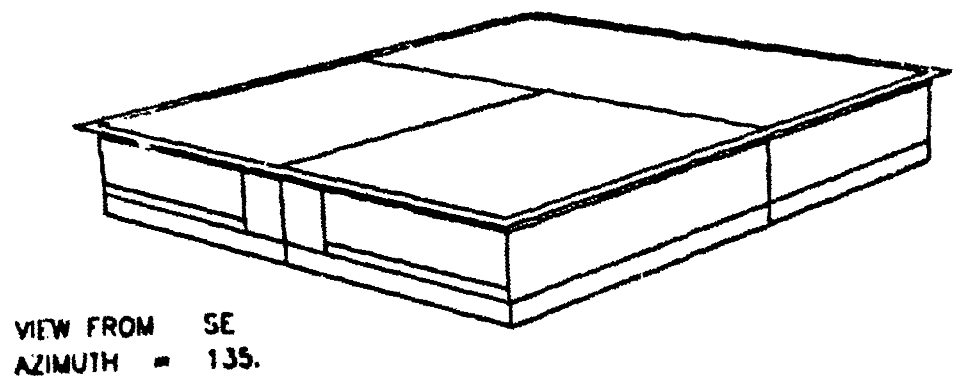

Fig. A-3. Isometric view of the Field House.

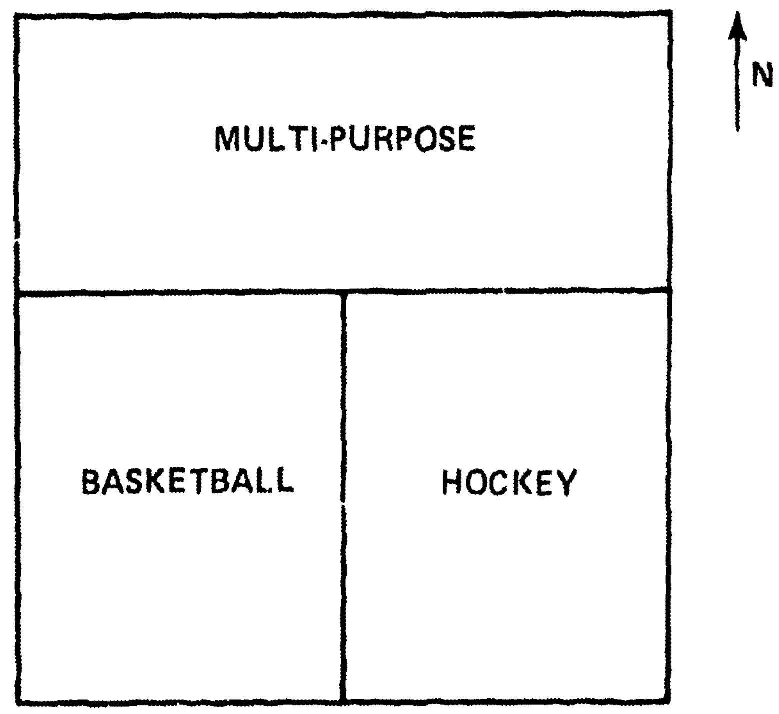

Fig. A-4. Plan view of Field House.

There is no cooling equipment for the building. Table A-V shows the heating and ventilating equipment that support each of the three zones.

TABLE A-V

FIELD HOUSE ZONES

Building Zone	Floor Area (ft^2)	Volume (ft^3)	Major Supporting Air-Handling Equipment
Basketball Stadium	47,124	2,780,316	AH-1 through AH-8; AH-10; AH-36; EF-1 through EF-5.
Ice hockey arena	47,124	2,780,316	AH-11 through AH-18; EF-6 through EF-9.
Multipurpose/track	74,579	5,667,980	AH-20 through AH-31; EF-10 through EF-13.

based on the outside air temperature. When a zone is operating in the ventilation mode and the outside air temperature is above 75°F, the air-handling units for that zone will return to the recirculation mode.

3. PLANT input. The high-temperature water supplied through converters to the ethylene glycol distribution system of the Field House was simulated by the steam utility option of the DOE-2.1A program. Energy consumed at the source was calculated by taking the DOE-2.1A results for steam consumption and dividing by an overall generation and distribution efficiency of 70%. A dummy centrifugal chiller was specified in PLANT to prevent the program from aborting.

An active solar system for the building's domestic hot water (DHW) load was simulated. Four parametric runs were made with varying values for the collector area, collector fluid flow rate, and storage tank volume. Approximately 77% of the building's DHW load can be met with 5000 ft^2 of collectors.

C. Aeronautics Laboratory

1. LOADS input. The building was divided into zones based on the internal loading, exterior surface type, solar exposure, and HVAC system type. Figure A-5 is an isometric view of the Aero Lab, as modeled, that was created by the development version of DOE-2.1A. Figures A-6 and A-7 contain a floor plan showing the zoning divisions. Schedules were input for lights, equipment, and people occupancy. Infiltration was assumed to occur only in the lobbies during the day as the central HVAC system supporting the rest of the building uses at least 12% fresh air during this period. This implied that the building

is under positive pressure. Some infiltration throughout the building was assumed to occur at night when the HVAC system is in the recirculation mode.

2. SYSTEMS input. Schedules fc thermostat set points and HVAC outside air requirements were input. Because only one HVAC system is permitted per thermal zone, the lobbies were split into a skin zone serviced by the unit heaters and a central zone. Size, operating parameters, and outside air requirements and coil set points for all systems were determined from the drawings and field inspections.

Two developmental modifications to the DOE-2.1A SYSTEMS program were used to simulate two of the options. These include the spray-coil and evaporative cooling routine and the Trombe wall simulation routine.

3. PLANT input. The medium-temperature hot water was simulated using the utility option of the DOE-2.1A program. The energy use values reported are the number of Btu's of hot water required at the building boundary.

The chilled water demand was converted to equivalent high-temperature hot water and electricity demands by simulating a single-effect absorption chiller that was sized by the program to just meet the peak cooling load. The energy use values reported are the number of Btu's of hot water and electricity required to produce the needed chilled water at the building boundary.

III. SUMMARY OF PERFORMANCE RESULTS - VANDENBERG HALL

Fourteen ECO candidates were analyzed for Vandenberg Hall; thirteen of these involved conservation modifications and one involved a solar modification.

Conservation Option	Description
2	Reinstate economizer operation for cadet store
3	Zone thermostat control for baseboard heaters
4	Tunnel preheat of ventilation air
5	Reinstate radiant heating in assembly areas
6	Run-around heat recovery loop

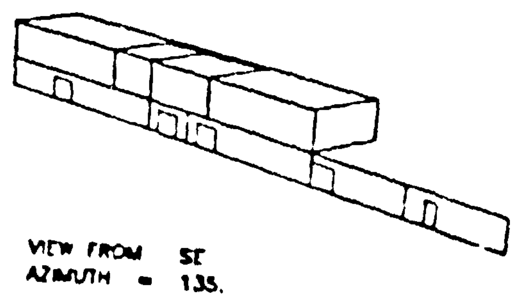

Fig. A-5. Isometric view of the Aero Lab.

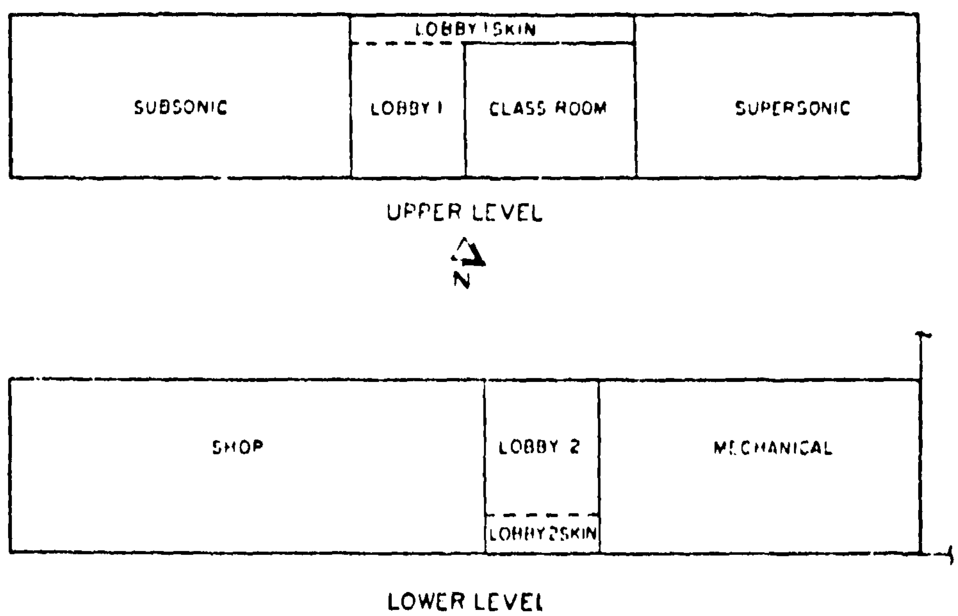

Fig. A-6. Plan view of the Aero Lab main buildings.

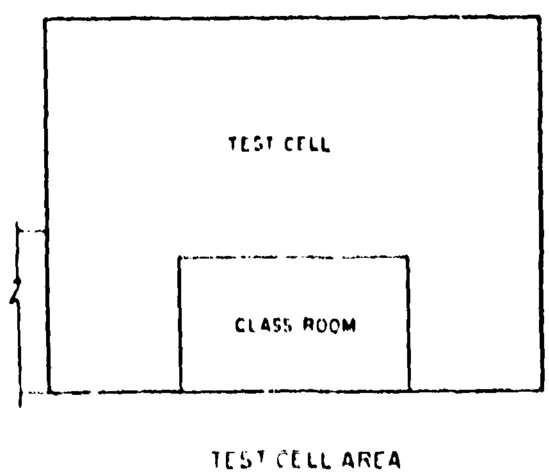

Fig. A-7. Plan view of a typical Aero Lab test cell.

Conservation Option	Description
7	Minimize ventilation rates
8	Improve fan/motor efficiency
9	Night insulation on windows
10	Improve wall and roof insulation
11	Combine options 6 and 7
12	Combine options 6, 7, and 8
13	Combine options 6, 7, 8, and 2
14	Combine options 6, 7, 8, 2, and 3

Solar Option	Description
2	Solar DHW system

The results of the computer analysis of these options are tabulated in Tables A-VI and A-VII. The individual options are discussed below.

A. Energy Conservation Opportunities (ECOs)

Table A-VI is a comparison of the energy conservation options considered and the expected energy consumption of each. An explanation of each follows.

1. Baseline building, as-built. A baseline building simulation was run on the existing building; energy consumed for heating was shown to be the predominant energy problem. The cooling load, by comparison, was shown to be quite small. The Building Boundary Energy Index was calculated at 55,800 Btu per gross square foot of floor area on an annual basis. This indicates that the building is very energy efficient and therefore difficult to retrofit with energy conservation features in a cost-effective manner.

2. Reinstate economizer operation for cadet stores. An economizer cycle providing free ventilative cooling was simulated in lieu of closed fresh air dampers associated with the multizone air-handling system supporting the cadet stores. These dampers were set by maintenance personnel to close when the outdoor temperature dropped below 60°F.

3. Zone thermostats for baseboard heaters. This option involves the control of the thermal output of the baseboard heaters by individual zone

TABLE A-VI

ENERGY CONSERVATION OPTIONS
VANDENBERG HALL

Option	Heating Energy (10^6 Btu)	Cooling Energy (10^6 Btu)	Electric Energy (10^6 Btu)	Building Boundary Energy Index (10^3 Btu/ft^2-yr)
1. Baseline, as-built	27,871	983	13,553	55.8
2. Reinstate economizer	27,874	915	13,521	55.7
3. Zone thermostats for baseboard heaters	26,024	983	13,404	53.2
4. Tunnel preheat of ventilation air	25,854	984	13,531	53.1
5. Reinstate radiant heating	28,092	983	13,067	56.4
6. Run-around heat recovery loop	14,193	983	13,382	37.6
7. Minimize ventilation rate	18,787	984	13,465	43.7
8. Improve fan/motor efficiencies	27,671	983	12,237	54.1
9. Night insulation on windows	27,388	994	13,537	55.2
10. Improve wall and roof insulation	27,678	999	13,550	55.6
11. Combine options 6 and 7	12,392	984	13,371	35.2
12. Combine options 6, 7, and 8	12,392	984	12,053	33.5
13. Combine options 6, 7, 8, and 2	12,398	915	12,021	33.3
14. Combine options 6, 7 8, 2, and 3	11,393	915	11,894	31.8

TABLE A-VII

SOLAR OPTIONS
VANDENBERG HALL

Option	Heating Energy (10^6 Btu)	Cooling Energy (10^6 Btu)	Electric Energy (10^6 Btu)	Building Boundary Energy Index (10^3 Btu/ft^2-yr)
1. Baseline, as-built	27,871	983	13,553	55.8
2. Solar domestic hot water system	24,050	983	13,636	53.4

thermostats instead of the outdoor temperature reset control now installed. This strategy eliminates the overheating that often occurs with reset control.

4. Tunnel preheat of ventilation air. This simulation assumed that the building was pressurized to eliminate infiltration. Such a feature could be implemented by drawing in air from the adjacent high-temperature hot water utility tunnel and delivering 70°F air to the space. Hence, infiltration would be displaced by ventilation air preheated by the thermal losses of the high-temperature water piping within the utility tunnel system.

5. Reinstate radiant heating. The assembly areas were previously heated by a radiant floor panel system that has been rendered inoperative. This option involved turning off the heating and ventilation units that now serve these areas and reviving the floor panel system. Fan power savings are realized but higher thermal losses offset some of these gains.

6. Run-around heat recovery loop. A run-around heat recovery system was simulated operating at an overall effectiveness of 75%. This option assumes that heat from the exhaust of ventilation air from the CENTRAL system is recovered and used to preheat the makeup air. This option yields the largest uncoupled energy savings of any considered.

7. Minimize ventilation rates. The ventilation rate for the CENTRAL system was reduced from 108,460 cfm to 50,812 cfm. Acceptable air quality can still be maintained even at the lower rates. This option will most likely yield the largest energy savings for the lowest capital expenditure.

8. Improve fan/motor efficiencies. Fan power savings were realized by assuming that a 50% savings in fan/motor energy could be realistically achieved by installing new fans and motors.

9. Night insulation on windows. This simulation assumed that R-9 insulation was applied to every window of the building at night to minimize heat loss. This strategy was mistakenly applied to both the summer and winter periods and the results show the consequential rise in cooling energy requirements. However, only a small amount of heating energy is saved, so this option was not rerun.

10. Improve wall, floor, and roof insulation. We simulated the installation of an additional R-3 of insulation on roof and floors of this building. The thermal resistance of the exterior walls was improved from R = 7 to R = 14. The addition of insulation results in only insignificant reduction of heat loss

in both the winter and summer. Although there is some heating energy performance improvement, there is also a cooling penalty to be paid.

11. Combine options 6 and 7. This option involves the installation of a run-around heat recovery system in addition to the reduction of the ventilation rate for the CENTRAL system. Significant thermal energy savings are realized by this combination.

12. Combine options 6, 7, and 8. The thermal energy savings features of the previous option are combined with improved fan/motor efficiency to yield both thermal and electrical energy savings.

13. Combine options 6, 7, 8, and 2. The thermal and electrical energy savings features of the previous option are combined with the reinstatement of the economizer cycle for the cadet stores.

14. Combine options 6, 7, 8, 2, and 3. Option 13 is combined with thermostatic control of the baseboard heaters for only slight performance improvement and relatively large first cost.

B. Solar Opportunities (ECOs)

Table A-VII compares the energy consumed by the baseline building to the energy consumed by the same building with a solar collector system of 40,000 ft^2 of collector providing 80% of the DHW energy requirements. Solar DHW systems generally cost about $50/$ft^2$ of collector installed and cannot be justified unless fuel prices increase significantly.

IV. SUMMARY OF PERFORMANCE RESULTS - FIELD HOUSE

Six ECO candidates were analyzed for the Field House; five of these were conservation modifications and one was an active solar retrofit.

Conservation Option	Description
2	Pressurize building with preheated air
3	Reduce thermostat set points in two zones
4	Add insulation to building roof
5	Combine options 2 and 3
6	Combine options 2, 3, and 4

Solar Option	Description
2	Active solar DHW retrofit

The results of the computer analysis of these options are shown in Tables A-VIII and A-IX. The individual options are discussed below.

A. Energy Conservation Opportunities (ECOs)

From the results of the energy survey and the DOE-2.1 simulation, an initial list of potential ECOs was compiled for the Field House. The ten potential ECOs for the Field House are as follows.

(1) Passive solar Trombe wall on south side to preheat outside air.

(2) Addition of insulation to roof of building.*

(3) Addition of insulation to walls of building.

(4) Reduction of lighting levels by the use of daylighting techniques (skylights).

(5) Reduction of building thermostat set points (to 62°F).*

(6) Active solar retrofit for the DHW load.*

(7) Exhaust fan heat recovery loop.

(8) Pressurize the building with prewarmed air to offset infiltration losses.*

(9) Recirculate warm air from the top of the high bays to the floor level.

(10) Waste heat recovery from the ice rink chiller to heat domestic hot water.

Outside air is brought into the building only during athletic and other events, and these occur most often at night. At these times, the amount of outside air required is so large as to make the contribution from a Trombe wall insignificant (< 10%).

The heating load caused by conduction through the walls was less than the load caused by conduction through the roof. It was decided to analyze the effect of adding roof insulation first, and if that turned out to be economically feasible, to then consider additional wall insulation.

If daylighting techniques are to be attempted for this building, they must be in the form of skylights through the roof, as any wall penetration would damage the architectural integrity of the building. Because of the height of the roof above the occupied space and the number of ceiling-level obstructions, there is insufficient light available through the use of

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*ECOs selected for further study.

TABLE A-VIII

ENERGY CONSERVATION OPTIONS
FIELD HOUSE

Option	Heating Energy (10^6 Btu)	Cooling Energy (10^6 Btu)	Electric Energy (10^6 Btu)	Building Boundary Energy Index (10^3 Btu/ft^2-yr)
1. Baseline	15,078	0	6,928	89.4
2. Pressurize building	7,698	0	6,928	59.4
3. Reduce thermostat setting	12,432	0	6,657	77.6
4. Add roof insulation	14,045	0	6,855	84.9
5. Combine options 2 and 3	6,129	0	6,769	52.4
6. Combine options 2, 3, and 4	5,243	0	6,669	48.5

TABLE A-IX

SOLAR OPTIONS
FIELD HOUSE

Option	Heating Energy (10^6 Btu)	Cooling Energy (10^6 Btu)	Electric Energy (10^6 Btu)	Building Boundary Energy Index (10^3 Btu/ft^2-yr)
1. Baseline	15,078	0	6,928	89.4
2. Solar domestic hot water system (5000 ft^2 collector area)	14,678	0	7,012	88.2

skylights to economically offset the daytime lighting energy. The building has already undergone two delampings and is currently operating at a very efficient lighting level.

Because the exhaust fans are running only when the building is in a ventilation mode and does not require additional heat, a heat recovery loop on the exhaust fans is not practical. The installation of fans to destratify air in the zones is also unnecessary because the building normally operates in a fully mixed 100% recirculation mode.

Water leaves the condenser of the ice rink chiller at approximately 68°F, too low a temperature to preheat domestic hot water. Table A-VIII is a comparison of the energy conservation options considered for further study and the expected energy consumption of each. An explanation of each option follows.

1. Baseline building, as-built. A baseline building simulation was run on the existing building, and energy loss caused by infiltration was shown to be the largest component of the building energy consumed for heating. The Building Boundary Energy Index was calculated at 89,438 Btu per gross square foot of floor area on an annual basis. This high number results from the very large volume of the building in comparison with its floor area.

2. Pressurize building with preheated air. The building was simulated assuming a supply of preheated outside air that would offset 60% of the infiltration losses. The air would be preheated by being drawn through the high-temperature hot water utility tunnel adjacent to the building. Heat recovery equipment including exchangers, fans, and ductwork would be installed to allow the existing air-handling equipment in each of the zones to distribute this preheated air.

Calculations were made assuming a 350°F water temperature, two 6-in.-diam pipes per utility tunnel, 1-1/2 in. of insulation on the pipes, and a maximum of 10 mph air flow in the tunnels. Using these assumptions and a 70 degree day base, it was estimated that approximately 4000 linear feet of tunnel would be required to obtain the necessary amount of preheat. The high energy savings and economic payback for this ECO make it an attractive retrofit project.

It has been learned that subsequent to this study, the Air Force Academy completed a retrofit project to install an additional 2 in. of fiber glass to the water pipes in the utility tunnel adjacent to the Field House. The reduced heat loss available for recovery would increase the length of utility tunnel required to 13,400 linear feet.

3. Reduce thermostat set points in two zones. Reduction of thermostat set points in the basketball stadium and the multipurpose/track facility from 70 and 65°F, respectively, to the set point currently maintained in the hockey rink (62°F) was simulated. This is a no-cost option and is recommended for immediate trial implementation to determine if the 62°F temperature proposed does not cause discomfort to the building's occupants.

4. Add insulation to building roof. The addition of 4 in. of insulation to the roof of the building was simulated. This option reduced only the heating energy loss caused by conduction through the roof, which was a minor contributor to the total building loss. This is an expensive option with relatively low energy savings.

5. Combine options 2 and 3. The thermal energy savings of providing preheated air to offset infiltration losses was combined with a reduction in thermostat set points to yield both thermal and electrical energy savings.

6. Combine options 2, 3, and 4. Option 5 is combined with the addition of roof insulation for additional thermal and electrical energy savings.

B. Solar Opportunities (ECOs)

Table A-IX compares the energy consumed by the baseline building with the energy consumed by the same building with a 5000 ft^2 active solar collector system providing 77% of the DHW energy requirements. Solar DHW systems generally cost about \$50/ft^2 of collector installed and are therefore too expensive for the energy saved to be economically justifiable.

V. SUMMARY OF PERFORMANCE RESULTS - AERONAUTICS LABORATORY

Eleven ECO candidates were analyzed for the Aeronautics Laboratory; six of these involved conservation modifications and five involved solar modifications.

Conservation Option	Description
3	Seasonal heating and cooling
4	Night setback in lobbies
5	Demand control
6	Evaporative cooling
7	Combine options 3 and 5
8	Combine options 3, 5, and 6

Solar Option	Description
2	Daylighting
3	Trombe wall
4	Sunspaces for the test cell class rooms
5	Active solar heating system
6	Solar domestic hot water heater

The results of the computer analysis of these options are tabulated in Tables A-X and A-XI. The individual options are discussed below.

A. Energy Conservation Opportunities (ECOs)

Table A-X is a comparison of the energy conservation options considered and the expected energy consumption of each. An explanation of each option is included below.

1. Baseline building, as designed. A baseline building simulation was run on the existing building using information obtained from drawings and a site visit. Results of this simulation and the site visit indicated a severe overheating problem in the room with the subsonic wind tunnel. This overheating was resulting in overcooling of other areas in the building as the heating and cooling systems attempt to keep that single room under control.

2. Adjusted baseline building. The baseline building from (1) above was rerun to incorporate all of the operational changes that could be made in this building at no capital cost to the Air Force. Furthermore, the installation of a separate air conditioning system in support of the subsonic wind tunnel area is assumed in this simulation to create a climate conducive to education. Increasing the size of the multizone system currently supporting this area will not correct the overheating problem in this room because the existing cooling coil, fan, motor, and ductwork are not adequate to handle the required increased air flow. This adjusted baseline was used for comparison of all other options because it represents the actual required energy consumption for the existing configuration.

This simulation assumes that the thermostats in the Shop, Combustion, Trisonic, and Lobby-1 areas are adjusted to control the temperature within these spaces between 68 and 78°F; that is, controlling over a 10°F throttling range during the day. At night, the multizone fan supporting these zones is shut off, but cycles on as needed to keep the temperature in these spaces above 60°F. The fan operation remains unchanged from the baseline simulations,

TABLE A-X

ENERGY CONSERVATION OPTIONS
AERONAUTICS LABORATORY

Option	Heating Energy (10^6 Btu)	Cooling Energy (10^6 Btu)	Electric Energy (10^6 Btu)	Building Boundary Energy Index (10^3 Btu/ft^2-yr)
1. Baseline, as designed	1176	590	2430	167.0
2. Adjusted baseline	992	554	2633	166.3
3. Seasonal heating and cooling	888	467	2625	15[illegible].4
4. Night setback in lobbies	956	548	2636	164.8
5. Demand control	758	511	2634	155.3
6. Evaporative cooling	1540	148	2624	171.6
7. Combine options 3 and 5	698	462	2627	150.7
8. Combine options 3, 5, and 6	698	0	2592	130.9

TABLE A-XI

SOLAR OPTIONS
AERONAUTICS LABORATORY

Option	Heating Energy (10^6 Btu)	Cooling Energy (10^6 Btu)	Electric Energy (10^6 Btu)	Building Boundary Energy Index (10^3 Btu/ft^2-yr)
1. Adjusted baseline	992	554	2633	166.3
2. Daylighting	1059	546	2489	16[illegible].9
3. Trombe wall	887	522	2618	160.3
4. Sunspace for test cell class rooms	959	555	2632	16[illegible].0
5. Active solar heating	270	554	2648	138.2
6. Solar DHW, 120 ft^2, 215 gal.	992	554	2621	165.9

but the temperature control was originally designed to maintain 70°F during the day and 60°F at night. These thermostats are currently set at 69°F during the day and 60°F at night.

The thermostat control of temperature in the test cell classrooms is adjusted to the same operation specified for the Shop, Combustion, Trisonic, and Lobby-1 areas. Historically, the test cell classrooms were maintained at 72.5 ± 2.5°F during the day and 62.5 ± 2.5°F at night and are currently set at 68°F during the day and 60°F at night. The fan operation remains unchanged.

In this simulation, the subsonic area is uncoupled from the multizone fan system currently supporting it and the Shop, Combustion, Trisonic, and Lobby-1 areas. The Subsonic room is heated when the temperature drops below 68°F in the day and 60°F at night. Cooling is provided when the temperature exceeds 78°F; a two position thermostat with a 10°F deadband is assumed to maintain this control. A single zone heating and cooling system continuously delivers 35,000 cfm of air during the day; at night the fan is shut off but cycles on automatically to keep the space above 60°F.

Finally, the hot and cold deck temperatures for the multizone system are adjusted from 120 to 100°F for heating and from 54 to 64°F for cooling. Our simulations show that thermal comfort is not reduced by this adjustment and that energy waste is avoided by not mixing air that is too hot with air that is too cold.

3. Seasonal heating and cooling. The option automatically shuts down the heating system whenever the outdoor temperature exceeds a certain setpoint (say 60°F) and starts the cooling system. Conversely, the opposite occurs when the temperature drops below that setpoint; that is, the heating system is initiated and the cooling system is shut down. This can be accomplished by interlocking the electric power supplied to the hot water pumps P-1 and P-2 with an outdoor temperature sensor. The cooling system must be controlled with a pneumatically operated isolation valve also interlocked with the outdoor temperature sensor. This option eliminates simultaneous heating and cooling in the multizone system S1 without reducing occupant comfort.

4. Night setback in the lobbies. Two unit heaters support the lobbies on the first and second floor of this building. Each is set to maintain a continuous 68°F temperature within the space. These unit heaters were setback to 60°F at night in the simulation. Although energy is saved by this setback,

the maximum investment allowable is only $3,695: consequently, this option is not recommended for implementation.

5. Demand control. This option involves adjusting the temperature of the hot and cold deck coils of the central multizone system. This temperature adjustment is done by a comparison of the temperature of each zone in the system. The temperature of the hot deck will be adjusted to just meet the requirements of the coldest zone and the cold deck temperature will be adjusted to just meet the requirements of the warmest zone. This strategy can result in an energy savings if either coil set point is not at an optimum temperature or if the optimum temperature changes.

Implementation would require installation of a comparitor microprocessor to compare the zone temperatures and to control the existing coil valves. These temperatures are already transmitted to the mechanical room for use in modulating the zone dampers.

This strategy would involve a relatively low investment and results in a 24% savings in heating energy and a 1% savings in cooling energy, representing the greatest savings of any single option considered.

6. Direct evaporative cooling. This option involves installation of an evaporative cooler in the Subsonic Wind Tunnel Room and addition of an air washer to the main S1 system in the Mechanical Room.

Evaporative cooling in these two area reduces the mechanical cooling requirements but, because of the uncontrolled cooling output of the evaporative cooling systems, the heating is increased. A two-speed fan for both evaporative systems would reduce the heating requirement.

7. Combine options 3 and 5. This option combines seasonal heating and cooling and demand control of the multizone system S1. See (3) and (5) above.

8. Combine options 3, 5, and 6. This option combines seasonal heating and cooling, demand control of system S1, and evaporative cooling in system S1 and the Subsonic Wind Tunnel Room. See (3), (5), and (6) above.

This combination is particularly advantageous because it prevents the heating system from tempering the uncontrolled output of the evaporative cooling systems. Evaporative cooling is assumed to operate only after the heating system is turned off. The installation of a two- or three-speed fan could reduce the overcooling that occurs during the spring and fall.

This combined strategy results in the largest energy saving of any of the options or combination of options analyzed. Furthermore, this strategy allows the building to be completely severed from the cooling water supplied from Fairchild Hall. The ventilative and evaporative resource at this site is sufficient to meet the cooling requirements of the Aeronautics Laboratory.

B. Solar Opportunities (ECOs)

Table A-XI is a comparison of the solar options considered. The table includes the expected energy consumption of the building when retrofitted with each option. An explanation of each option is included below.

1. Adjusted baseline. See explanation under Item 2 of the Energy Conservation Opportunities.

2. Daylighting. Lighting levels were reduced to 1.2 watts/ft^2 to assess the potential daylighting savings; this action would involve installation of windows or skylights. This option only slightly decreases the cooling and electrical energy consumption and slightly increases the heating energy requirements. Because implementation of this option would require major architectural changes and result in very little savings, it is not recommended as a candidate ECO.

3. Trombe wall. An unvented Trombe wall was modeled in the existing south facing walls of the lower and upper level lobbies, shops, classroom, storage, and trisonic rooms. The Trombe wall was assumed to be constructed of double pane glass and the walls were painted flat black. The glazing was assumed to be shaded during the summer.

The amount of energy displaced by the 4,362 ft^2 of Trombe wall simulated would not justify an investment of more than $4.00 per square foot of glazing. Therefore, this option is not recommended as a candidate ECO.

4. Sunspace for the test cell classrooms. The entry ways to the test cell classrooms were converted into sunspaces by eliminating the exterior concrete walls in front of the test cell classrooms and replacing them with double-glazed patio doors and applying R-9 insulation at night.

The amount of energy displaced by the 637 ft^2 of vertical glazing simulated would not justify an investment of more than $5.25 per square foot of glazing. Therefore, this option is not recommended as a candidate ECO.

5. Active solar heating system. An active solar water heating system was added assuming that all of the hot water coils in the conventional heating system would be replaced by larger coils delivering their rated output with

solar heated water supplied at 120°F. The solar system consists of approximately 6,000 ft^2 of single-glazed, selective-surface, flat-plate collectors, and a 10,800-gal. storage tank.

This option can supply as much of the space heating needs of the building as desired by adjusting the size of the collectors and storage tank. The 6,000 ft^2 of collectors with 10,600 gal. of storage would provide 73% of the space heating requirements of the building with only a slight increase in electrical energy consumption. However, the cost of implementing this option would more than exceed the economic benefit of the fuel savings over the assumed 25-year economic life of the solar collecting system.

6. Solar DHW heater. A solar DHW heater was added to the adjusted baseline to supplement the electric DHW heaters. A very minor decrease in electrical consumption was achieved as the DHW load is a very small part of the load. This option is not recommended as a candidate ECO.

VI. BASELINE COMPUTER MODEL LISTINGS

The baseline computer input for Vandenberg Hall, the Field House, and the Aeronautics Laboratory is attached as pages 42-81.

LOADS INPUT

L D L   P R O C E S S O R   I N P U T   D A T A

81/09/14   15:26:04   LDL RUN 1

```
  TITLE LINE-1 = * VANDENBERG HALL *
        LINE-2 = * AIR FORCE ACADEMY *
        LINE-3 = * COLORADO SPRINGS, COLO *  ..
  RUN-PERIOD=JAN 1 1978 THRU DEC 31  1978  ..
ABORT ERRORS  ..
DIAGNOSTIC CAUTIONS  ..

  BUILDING-LOCATION    LATITUDE=39      LONGITUDE=105
                       ALTITUDE=7150    TIME-ZONE=7
                       AZIMUTH=0   ..

          $  SCHEDULES  $
  $  DRAPES  $
    DS1=DAY-SCHEDULE
      (1,7) (0.64) (8,18) (1.0) (19,24) (0.64)
    DRAPESCHED=SCHEDULE THRU DEC 31 (ALL) DS1   .
  $  PEOPLE  $
    DS2=DAY-SCHEDULE
      (1,7)(.77)(8,16)(.11)(17,18)(.88)(19)(.06)(20,24)(.88)   ..
    DS3=DAY-SCHEDULE
      (1,7)(.77)(8)(.07)(9,11)(.66)(12)(.07)(13,18)(.92)(19)(.07)
      (20,24)(.79)   ..
    PEOSCHED=SCHEDULE THRU DEC 31 (WD) DS2 (WEH) DS3   .
    DS6=DAY-SCHEDULE
      (1,7)(0)(8,12)(0.5)(13)(1.0)(14,18)(.8)(19,24)(0)
    PEOSCHED2=SCHEDULE THRU DEC 31 (ALL) DS6   ..

  DS8=DAY-SCHEDULE
    (1,7)(.25)(8,14)(.12)(15,16)(1.0)(17,18)(.25)(19)(.05)
    (20,24)(.25)
  DS9=DAY-SCHEDULE
    (1,7)(.25)(8,16)(.12)(17,18)(.25)(19)(.05)(20,24)(.25)   .
  PEOSCHED3=SCHEDULE THRU DEC 31 (WD) DS8 (WEH) DS9   ..
  DS10=DAY-SCHEDULE  (1,12)(0)(13,16)(1)(17,24)(0)   .
  DS11=DAY-SCHEDULE  (1,24)(0)   ..
  PEOSCHED4=SCHEDULE THRU DEC 31 (WD) DS10 (WEH) DS11   .

  $  LIGHTS  $
    DS4=DAY-SCHEDULE
      (1,7)(0.1)(8,16)(0.2)(17,18)(0.55)(19,24)(1.0)   .
    LIGHTSCHED=SCHEDULE THRU DEC 31 (ALL) DS4   .
    DS7=DAY-SCHEDULE
      (1,7)(0)(8,18)(1.0)(19,24)(0)
    LEQSCHED=SCHEDULE THRU DEC 31 (ALL) DS7   .

  $  SOURCE  $
    DS5=DAY-SCHEDULE
      (1,5)(0)(6)(1)(7,21)(0)(22,24)(1)   .
    SRCSCHED=SCHEDULE THRU DEC 31 (ALL) DS5   .
  $  PRINT  $
    PRINTSCHED=SCHEDULE THRU JAN  5 (ALL) (1,24) (1)
                        THRU MAR 31 (ALL) (1,24) (0)
                        THRU APR  5 (ALL) (1,24) (1)
                        THRU DEC 31 (ALL) (1,24) (0)  ..
```

```
        $  LAYERS  $
LAYS1=LAYERS  MATERIAL=(BR01,IN71,IN76,CC6)  ..
LAYS2=LAYERS  MATERIAL=(CC13,IN71,IN76,CC06)  ..
LAYS3=LAYERS  MATERIAL=(CC05,IN35)  ..
LAYS4=LAYERS MATERIAL=(CC05,IN41,AL11,ST01)

        $  CONSTRUCTION  $
CONSWINDOW=CONSTRUCTION
  U-VALUE=0.135    ABS=0.3  ..
CONSROOF56W=CONSTRUCTION
  LAYERS=LAYS1  ..
CONSFLOR56W=CONSTRUCTION
  LAYERS=LAYS2  ..
GLAZING=GLASS-TYPE
  PANES=2    G-T-C=6  ..
GLAZING2=GLASS-TYPE
  PANES=1  G-T-C=6  G-C-0.6  ..
CONSUGW=CONSTRUCTION  LAYERS=LAYS3  ..
CONS23S1=CONSTRUCTION LAYERS=LAYS4  ..
IWALL=CONSTRUCTION  U-VALUE=0.32  ..

        $  SPACE CONDITIONS  $
COND56W=SPACE-CONDITIONS
  NUMBER-OF-PEOPLE=800
  PEOPLE-HEAT-GAIN=400
  PEOPLE-SCHEDULE=PEOSCHED
  LIGHTING-W/SQFT=0.75
  LIGHTING-TYPE=INCAND
  LIGHTING-SCHEDULE=LIGHTSCHED
  SOURCE-BTU/HR=1092500
-CAUTION------------------------ ******* -------------------------------------
-CAUTION--- VALUE GREATER THAN MAXIMUM OF    0.1000E+07
  SOURCE-LATENT=0.3
  SOURCE-SENSIBLE=0.3
  SOURCE-SCHEDULE=SRCSCHED
  INF-METHOD-AIR-CHANGE
  AIR-CHANGES/HR=0.25
  TEMPERATURE=(65)
  FLOOR-WEIGHT=175  ..

COND56E=SPACE-CONDITIONS LIKE=COND56W EXCEPT
  NUMBER-OF-PEOPLE=400  SOURCE-BTU/HR=546250

COND23W=SPACE-CONDITIONS LIKE-COND56W  ..

COND23E=SPACE-CONDITIONS LIKE=COND56E  ..

COND23S=SPACE-CONDITIONS
  TEMPERATURE=(65)
  NUMBER-OF-PEOPLE=60
  PEOPLE-HEAT-GAIN=400
  PEOPLE-SCHEDULE=PEOSCHED2
  LIGHTING-W/SQFT=2.0
  LIGHTING-TYPE-INCAND
  LIGHTING-SCHEDULE=LEQSCHED
  EQUIPMENT-W/SQFT=0.75
  EQUIP-SCHEDULE-LEQSCHED
  INF-METHOD-AIR-CHANGE
  INF-CFM/SQFT=0.0
  FLOOR-WEIGHT=175  ..
```

```
CONO22N=SPACE-CONDITIONS
TEMPERATURE=(65)
NUMBER-OF-PEOPLE=100
PEOPLE-HEAT-GAIN=400
PEOPLE-SCHEDULE=PEOSCHED3
LIGHTING-W/SQFT=1.0
LIGHTING-TYPE=INCAND
LIGHTING-SCHEDULE=LIGHTSCHED
EQUIPMENT-W/SQFT=0.75
EQUIP-SCHEDULE=LEOSCHED
INF-METHOD=AIR-CHANGE
AIR-CHANGES/HR=0.25
FLOOR-WEIGHT=175 ..

COND4=SPACE-CONDITIONS
NUMBER-OF-PEOPLE=500
PEOPLE-HEAT-GAIN=400
PEOPLE-SCHEDULE=PEOSCHED4
LIGHTING-W/SQFT=1.0
LIGHTING-TYPE=INCAND
LIGHTING-SCHEDULE=PEOSCHED4
SOURCE-BTU/HR=10000
SOURCE-SCHEDULE=PEOSCHED4
INF-METHOD=AIR-CHANGE
AIR-CHANGES/HR=0.25
TEMPERATURE=(55)
FLOOR-WEIGHT=175 ..

        $  SHADING SURFACES  $
S56W-E1=B-S
  H=17.3 W=146 X=49.9 Y=50 Z=44.6 AZ=90 TILT=90 .
S56W-N1=B-S
  H=17.3 W=315 X=365 Y=49.9 Z=44.6 AZ=0 TILT=90 .
S56W-W2=B-S
  H=17.3 W=146 X=365.1 Y=196 Z=44.6 AZ=270 TILT=90 .
S56W-E2=B-S
  H=17.3 W=146 X=411.9 Y=50 Z=44.6 AZ=90 TILT=90 ..
S56W-N3=B-S
  H=17.3 W=316 X=731 Y=49.9 Z=44.6 AZ=0 TILT=90 .
S56W-W3=B-S
  H=17.3 W=146 X=731.1 Y=196 Z=44.6 AZ=270 TILT=90 .

S56E-E1=B-S
  H=17.3  W=146  X=1057.9  Y=50  Z=44.6  AZ=90  TILT=90 ..
S56E-N1=B-S
  H=17.3  W=230  X=1288  Y=49.9  Z=44.6  AZ=0  TILT=90 ..
S56E-W2=B-S
  H=17.3  W=146  X=1288.1  Y=196  Z=44.6  AZ=270  TILT=90 .

S56W-F1=B-S
  H=50 W=781 X=0 Y=0 Z=44.5 AZ=180 TILT=0 ..
S56W-F2=B-S  LIKE=S56W-F1 EXCEPT Y=196 .
S56W-F3=B-S
  H=146 W=50 X=0 Y=50 Z=44.5 AZ=180 TILT=0 .
S56W-F4=B-S  LIKE=S56W-F3 EXCEPT X=365 .
S56W-F5=B-S LIKE=S56W-F3 EXCEPT X=731
S56E-F1=B-S  H=50 W=330 X=1008 Y=0 Z=44.5 AZ=180 TILT=0
S56E-F2=B-S LIKE=S56E-F1 EXCEPT Y=196
S56E-F3=B-S LIKE=S56E-F1 EXCEPT Y=50 H=146 W=50
S56E-F4=B-S LIKE=S56E-F3 EXCEPT X=1288 .

S22WE-S-B-S
```

```
     S23E-E1=B-S LIKE=S56E-E1 EXCEPT Z=11.2 H=18.4 ..
     S23E-W2=B-S LIKE=S56E-W2 EXCEPT Z=11.2 H=18.4 ..
     S23E-N2=B-S LIKE=S56E-N1 EXCEPT Z=11.2 H=18.4 ..

     S23W-E1=B-S LIKE=S56W-E1 EXCEPT H=18.4 Z=11.2 ..
     S23W-W5=B-S LIKE=S23W-E1 EXCEPT X=731.1 Y=196 AZ=270 ..
   S56W-F6=B-S  X=0 Y=196 Z=44.5 AZ=180 TILT=0 H=50 W=781
   S56E-F5=B-S  X=1008 Y=196 Z=44.5 AZ=180 TILT=0 H=50 W=330 ..
   S4W=B-S  X=50 Y=206 Z=31 AZ=180 TILT=90 H=14 W=304 ..
   S4E=B-S  X=1058 Y=206 Z=31 AZ=180 TILT=90 H=14 W=133.6


          $  FIFTH & SIXTH FLOORS - WEST  $

   ZONE56W=SPACE
     X=0 Y=0 Z=44.6 AZ=0 AREA=200000 VOLUME=1700000
-CAUTION------------------------------------------------------------------------
-CAUTION--- VALUE GREATER THAN MAXIMUM OF      0.1000E+06
-CAUTION------------------------------------------------------------------------
-CAUTION--- VALUE GREATER THAN MAXIMUM OF      0.1000E+07
     SPACE-CONDITIONS=COND56W ..

   EW56W-W1=E-W
     CONS=CONSWINDOW  S-F-F=0.5  X=0  Y=246  Z=0  AZ=270
     TILT=90  HEIGHT=17.3  WIDTH=246  G-F-F=0.5  ..
   WIN56W-W1=WINDOW
     G-T=GLAZING  X=0  Y=5.92 H=5.456  W=246  S-F-F=0.5
     CONDUCT-SCHEDULE=DRAPESCHED  G-F-F=0.5  ..

   EW56W-W2=E-W
     CONS=CONSWINDOW  S-F-F=0.42  X=365  Y=196  Z=0  AZ=270
     TILT=90  H=17.3  W=146  G-F-F=0.58  ..
   WIN56W-W2=WINDOW
     LIKE=WIN56W-W1  EXCEPT W=146 S-F-F=0.42  G-F-F=0.58

   EW56-W3=E-W LIKE=EW56W-W2 EXCEPT X=731  ..
   WIN56W-W3=WINDOW LIKE=WIN56W-W2  ..

   EW56W-E1=E-W
     LIKE=EW56W-W2 EXCEPT X=50 Y=50 AZ=90  ..
   WIN56W-E1=WINDOW  G-T=GLAZING  X=0  Y=3.38  H=10.54  W=146
     S-F-F=0.42  CONDUCT-SCHEDULE=DRAPESCHED  G-F-F=0.58

   EW56W-E2=E-W LIKE=EW56W-E1 EXCEPT X=415  ..
   WIN56W-E2=WINDOW LIKE=WIN56W-E1  ..

   EW56W-E3=E-W
     LIKE=EW56W-W1 EXCEPT X=781 Y=0 AZ=90  ..
   WIN56W-E3=WINDOW LIKE=WIN56W-W1 EXCEPT Y=3.38  H=10.54

   EW56W-N1=E-W
     LIKE=EW56W-E1 EXCEPT X=365 Y=50 AZ=0  W=315 S-F-F=0.45
       G-F-F=0.55  ..
   WIN56W-N1=WINDOW LIKE=WIN56W-E1 EXCEPT W=315 S-F-F=0.45
       G-F-F=0.55  ..

   EW56W-N2=E-W LIKE=EW56W-N1 EXCEPT X=781 Y=246 S-F-F=0.5 W=781
       G-F-F=0.5  ..
   WIN56W-N2=WINDOW LIKE=WIN56W-E1 EXCEPT W=781  S-F-F=0.5
       G-F-F=0.5  ..

```

```
EW56W-N3=E-W LIKE=EW56W-N1 EXCEPT W=316 Y=731 ..
WIN56W-N3=WINDOW LIKE=WIN56W-N1 EXCEPT W=316 ..

EW56W-S1=E-W LIKE=EW56W-N2 EXCEPT X=0 Y=0 AZ=180 ..
WIN56W-S1=WINDOW LIKE=WIN56W-N2 ..

EW56W-S2=E-W LIKE=EW56W-S1 EXCEPT X=50 Y=196 S-F-F=0.45 W=315
    G-F-F=0.55 ..
WIN56W-S2=WINDOW LIKE=WIN56W-N1 ..

EW56-S3=E-W LIKE EW56W-S2 EXCEPT X=415 W=316 ..
WIN56W-S3=WINDOW LIKE=WIN56W-S2 EXCEPT W=316 ..

ROOF56W1=ROOF
  CONS=CONSROOF56W  S-F-F=1.0  X=0  Y=0  Z=17.3  AZ=180
  TILT=0  H=50  W=781  G-F-F=0  ..

ROOF56W2=ROOF LIKE=ROOF56W1 EXCEPT Y=196 ..

ROOF56W3=ROOF LIKE=ROOF56W1 EXCEPT Y=50 H=146 W=50 ..

ROOF56W4=ROOF LIKE=ROOF56W3 EXCEPT X=365 ..

ROOF56W5=ROOF LIKE=ROOF56W3 EXCEPT X=731 ..

FLOOR56W=F-W
  CONS=CONSFLOR56W  S-F-F=0  X=0  Y=246  Z=0  AZ=180  TILT=180
  H=246  W=338.8  G-F-F=1.0  ..

        $  FIFTH & SIXTH FLOOR - EAST  $

  ZONE56E=SPACE
    X=1008  Y=0  Z=44.6  AZ=0  AREA=95200
    VOLUME=809200  SPACE-CONDITIONS=COND56E  ..

  EW56E-W1=E-W
    CONS=CONSWINDOW  S-F-F=0.5  X=0  Y=246  Z=0  AZ=270
    TILT=90  H=17.3  W=246  G-F-F=0.5  ..
  WIN56E-W1=WINDOW
    G-T=GLAZING  X=0  Y=5.92 H=5.466  W=246  S-F-F=0.5
    CONDUCT-SCHEDULE=DRAPESCHED  G-F-F=0.5  ..

  EW56E-W2=E-W LIKE=EW56E-W1 EXCEPT X=280 Y=196 W=146
    S-F-F=0.42  G-F-F=0.58  ..
  WIN56E-W2=WINDOW LIKE=WIN56E-W1 EXCEPT W=146 S-F-F=0.42
    G-F-F=0.58

  EW56E-E1=E-W LIKE=EW56E-W2 EXCEPT X=50 Y=50 AZ=90 ..
  WIN56E-E1=WINDOW LIKE=WIN56E-W2 EXCEPT Y=3.38  H=10.54 ..

  EW56E-E2=E-W LIKE=EW56E-W1 EXCEPT X=330 Y=0 AZ=90
  WIN56E-E2=WINDOW LIKE=WIN56E-E1 EXCEPT W=246 ..

  EW56E-S1=E-W LIKE=EW56E-W1 EXCEPT Y=0 AZ=180 W=330 ..
  WIN56E-S1=WINDOW LIKE=WIN56E-E2 EXCEPT W=330

  EW56E-S2=E-W LIKE=EW56E-S1 EXCEPT X=50 Y=196 W=230 ..
  WIN56E-S2=WINDOW LIKE=WIN56E-E1 EXCEPT W=230 S-F-F=0.45
    G-F-F=0.55  ..

  EW56E-N1=E-W LIKE=EW56E-S2 EXCEPT X=280 Y=50 AZ=0 ..
```

```
      WIN56E-N1=WINDOW LIKE=WIN56E-S2  ..

      EW56E-N2=E-W LIKE=EW56E-S1 EXCEPT X=330 Y=246 AZ=0
      WIN56E-N2=WINDOW LIKE=WIN56E-S1  ..

      ROOF56E1=ROOF
        CONS=CONSROOF56W S-F F=1.0 X=0 Y=0 Z=17.3 AZ=180
        TILT=0 H=50 W=330  G-F-F=0.0

      ROOF56E2=ROOF LIKE=ROOF56E1 EXCEPT Y=196  ..

      ROOF56E3=ROOF LIKE=ROOF56E1 EXCEPT Y=50 H=146 W=50  ..

      ROOF56E4=ROOF LIKE=ROOF56E3 EXCEPT X=280  ..

      FLOOR56E=E-W
        CONS=CONSFLOR56W S F-F=0 X=0 Y=246 Z=0 AZ=180 TILT=180
        H=246 W=150.5  G-F-F=1.0  ..

            $  SECOND & THIRD FLOORS - WEST  $

      ZONE23W=SPACE
        X=0 Y=0 Z=11.2 AZ=0 AREA=229200 VOLUME=1948200
-CAUTION-------------------------------------------------------------------------
-CAUTION--- VALUE GREATER THAN MAXIMUM OF     0.1000E+06
-CAUTION-------------------------------------------------------------------------
-CAUTION--- VALUE GREATER THAN MAXIMUM OF     0.1000E+07
        SPACE-CONDITIONS=COND23W  ..

      EW23W-W1=E-W
        CONS=CONSWINDOW  S-F-F=0.5 X=0 Y=246 Z=0 AZ=270
        TILT=90 H=18.4 W=246  G-F-F=0.5  ..
      WIN23W-W1=WINDOW
        G-T=GLAZING X=0 Y=5.92 H=5.466 W=246 S-F-F=0.5
        CONDUCT-SCHEDULE=DRAPESCHED  G-F-F=0.5  ..

      EW23W-W2=E-W LIKE=EW23W-W1 EXCEPT X=197 Y=196 S-F-F=0.28
        W=146  G-F-F=0.72  ..
      WIN23W-W2=WINDOW LIKE=WIN23W-W1 EXCEPT W=146 S-F-F=0.28
        G-F-F=0.72  ..

      EW23W-W3=E-W LIKE=EW23W-W2 EXCEPT X=365  ..
      WIN23W-W3=WINDOW LIKE=WIN23W-W2  ..

      EW23W-W4=E-W LIKE=EW23W-W2 EXCEPT X=534  ..
      WIN23W-W4=WINDOW LIKE=WIN23W-W2  ..

      EW23W-W5=E-W LIKE=EW23W-W2 EXCEPT X=731  ..
      WIN23W-W5=WINDOW LIKE=WIN23W-W2  ..

      EW23W-E1=E-W LIKE=EW23W-W2 EXCEPT X=50  Y=50 AZ=90  ..
      WIN23W-E1=WINDOW LIKE=WIN23W-W2 EXCEPT Y=3.38  H=10.54  ..

      EW23W-E2=E-W LIKE=EW23W-E1 EXCEPT X=247  ..
      WIN23W-E2=WINDOW LIKE=WIN23W-E1  ..

      EW23W-E3=E-W LIKE=EW23W-E1 EXCEPT X=415  ..
      WIN23W-E3=WINDOW LIKE=WIN23W-E1  ..

      EW23W-E4=E-W LIKE=EW23W-E1 EXCEPT X=584  ..
      WIN23W-E4=WINDOW LIKE=WIN23W-E1  ..
```

```
      EW23W-E5=E-W LIKE=EW23W-E1 EXCEPT X=781 ..
      WIN23W-E5=WINDOW LIKE=WIN23W-E1 ..

      EW23W-N1=E-W LIKE=EW23W-W1 EXCEPT X=781 AZ=0 W=781 ..
      WIN23W-N1=WINDOW LIKE=WIN23W-W1 EXCEPT Y=3.38 H=10.54
        W=781 ..

      EW23W-N2=E-W LIKE=EW23W-E1 EXCEPT X=197 Y=50 AZ=0 W=147 ..
      WIN23W-N2=WINDOW LIKE=WIN23W-E1 EXCEPT W=147 ..

      EW23W-N3=E-W LIKE=EW23W-N2 EXCEPT X=365 W=120
      WIN23W-N3=WINDOW LIKE=WIN23W-N2 EXCEPT W=120 ..

      EW23W-N4=E-W LIKE=EW23W-N3 EXCEPT X=534 W=119 ..
      WIN23W-N4=WINDOW LIKE=WIN23W-N3 EXCEPT W=119 ..

      EW23W-N5=E-W LIKE=EW23W-N4 EXCEPT X=731 W=147 ..
      WIN23W-N5=WINDOW LIKE=WIN23W-N4 EXCEPT W=147 ..

      EW23W-S1=U-W
        A=14370  CONS=CONSUGW ..

      EW23W-S2=E-W LIKE=EW23W-N2 EXCEPT X=50 Y=196 AZ=180 ..
      WIN23W-S2=WINDOW LIKE=WIN23W-N2 ..

      EW23W-S3=E-W LIKE=EW23W-S2 EXCEPT X=247 W=120 ..
      WIN23W-S3=WINDOW LIKE=WIN23W-N3 ..

      EW23W-S4=E-W LIKE=EW23W-S2 EXCEPT X=415 W=119 ..
      WIN23W-S4=WINDOW LIKE=WIN23W-N4 ..

      EW23W-S5=E-W LIKE=EW23W-S2 EXCEPT X=584 ..
      WIN23W-S5=WINDOW LIKE=WIN23W-N5 ..

      ROOF23W1=ROOF
        CONS=CONSFLOR56W  S-F-F=0.5 X=0 Y=0 Z=18.4 AZ=180 TILT=0
        H=50 W=781.0  G-F-F=0.5 ..

      ROOF23W2=ROOF LIKE=ROOF23W1 EXCEPT Y=196  W=448.1 ..

      ROOF23W3=ROOF LIKE=ROOF23W1 EXCEPT Y=50 H=146 W=50 ..

      ROOF23W4=ROOF LIKE ROOF23W3 EXCEPT X=197 ..

      ROOF23W5=ROOF LIKE=ROOF23W3 EXCEPT X=365 ..

      ROOF23W6=ROOF LIKE=ROOF23W3 EXCEPT X=534 ..

      ROOF23W7=ROOF LIKE=ROOF23W3 EXCEPT X=731 ..

      FLOOR23W=E-W  CONS=CONSFLOR56W S-F-F=0 X=0 Y=246
        Z=0 AZ=180 TILT=180 H=246 W=277.4  G-F-F=1.0 ..

            $  SECOND AND THIRD FLOOR - EAST  $

      ZONE23E=SPACE
        X=1008 Y=0  Z=11.2  AZ=0  AREA=95200
        VOLUME=809200  SPACE-CONDITIONS=COND23E ..

      EW23E-W1=E-W  CONS=CONSWINDOW S-F-F=0.28 X=0
        Y=196 Z=0 AZ=270 TILT=90 H=18.4 W=146  G-F-F=0.72 ..
      WIN23E-W1=WINDOW  G-T=GLAZING X=0 Y=5.92 H=5.466
```

```
   W=146 S-F-F=0.28 CONDUCT-SCHEDULE=DRAPESCHED  G-F-F=0.72  ..

  EW23E-W2=E-W LIKE=EW23E-W1 EXCEPT X=280  ..
  WIN23E-W2=WINDOW LIKE=WIN23E-W1  ..

  EW23E-E1=E-W LIKE=EW23E-W1 EXCEPT X=50 Y=50 AZ=90  ..
  WIN23E-E1=WINDOW LIKE=WIN23E-W1 EXCEPT Y=3.38  H=10.54  ..

  EW23E-E2=E-W LIKE=EW23E-E1 EXCEPT X=330 Y=0 W=246
    S-F-F=0.5  G-F-F=0.5  ..
  WIN23E-E2=WINDOW LIKE=WIN23E-E1 EXCEPT W=246 S-F-F=0.5
    G-F-F=0.5  ..

  EW23E-N1=E-W LIKE=EW23E-E2 EXCEPT X=330 Y=246 AZ=0 W=330
  WIN23E-N1=WINDOW LIKE=WIN23E-E2 EXCEPT W=330

  EW23E-N2=E-W LIKE=EW23E-N1 EXCEPT X=280 Y=50 W=230
    S-F-F=0.28  G-F-F=0.72  ..
  WIN23E-N2=WINDOW LIKE=WIN23E-E1 EXCEPT W=230

  EW23E-S1=E-W LIKE=EW23E-N1 EXCEPT X=64 Y=0 AZ=180
    W=266  ..
  WIN23E-S1=WINDOW LIKE=WIN23E-N1  EXCEPT W=266  ..

  EW23E-S2=E-W LIKE=EW23E-N2 EXCEPT X=50 Y=196 AZ=180  ..
  WIN23E-S2=WINDOW LIKE=WIN23E-N2  ..

  ROOF23E1=ROOF  CONS=CONSROOF56W  S-F-F=0.5 X=0 Y=0
    Z=18.4 AZ=180 TILT=0 H=50 W=118.6  G-F-F=0.5

  ROOF23E2=ROOF LIKE=ROOF23E1 EXCEPT Y=196  W=330

  ROOF23E3=ROOF LIKE=ROOF23E1 EXCEPT Y=50 H=146 W=50

  ROOF23E4=ROOF LIKE=ROOF23E3 EXCEPT X=280  ..

  FLOOR23E=E-W  CONS=CONSFLOR56W S-F-F=0 X=0 Y=246
    Z=0  AZ=180 TILT=180 H=246 W=193.5  G-F-F=1.0

         $  FIRST THRU THIRD FLOORS - SOUTH  $

  ZONE23S=SPACE
    X=764 Y=-42 Z=0 AZ=0 AREA=85000 VOLUME=765000
    SPACE-CONDITIONS=COND23S  ..

  EW23S-N1=E-W CONS=CONS23S1 X=308 Y=92 Z=0 AZ=0 TILT=90
    H=11.3 W=308 S-F-F=0.25  G-F-F=0.75  ..

  EW23S-N2=E-W CONS=CONSWINDOW X=244 Y=92 Z=11.3 AZ=0
    TILT=90 H=18.4 W=227 S-F-F=0.25  G-F-F=0.75
WIN23S-N2=WINDOW  G-T=GLAZING X=0 Y=3.38  H=10.54 W=227
  S-F-F=0.4 G-F-F=0.6 CONDUCT-SCHEDULE=DRAPESCHED

  EW23S-W1=E-W CONS=CONS23S1 X=0 Y=92 Z=0 AZ=270 TILT=90 H=11.3
    W=92 S-F-F=0.2  G-F-F=0.8  .

  EW23S-W2=E-W CONS=CONS23S1 X=0 Y=42 Z=11.3 H=18.4 W=42
    AZ=270  TILT=90  S-F-F=0.35  G-F-F=0.65

  EW23S-S1=E-W  CONS=CONS23S1 X=0 Y=0 Z=0 AZ=180 TILT=90
    H=29.7 W=308 S-F-F=0.5  G-F-F=0.5
```

```
      EW23S E1=E-W  CONS=CONS23S1 X=308 Y=0 Z=0 AZ=90 TILT=90
        H=11.3 W=92 S-F-F=0.2  G-F-F=0.8 ..

      EW23S-E2=E-W CONS=CONS23S1 X=308 Y=0 Z=11.3 AZ=90 TILT=90
        H=18.4 W=42 S-F-F=0.35  G-F-F=0.65 ..

      FLOOR23S=U-F  AREA=800  CONS=CONSUGW ..

      ROOF23S=ROOF
        CONS=CONSROOF56W  S-F-F=0.75 X=0 Y=0 Z=29.7 AZ=180
        TILT=0 H=92 W=264  G-F-F=0.25

      IW23S-23E=I-W
        AREA=2097.6 CONSTRUCTION=IWALL NEXT-TO=ZONE23E ..

      IW23S-23W=I-W
        AREA=1233 CONSTRUCTION=IWALL NEXT-TO=ZONE23W ..

            $  SECOND AND THIRD FLOORS - NORTH  $

    ZONE23N=SPACE
      X=281 Y=196 Z=11.2 AZ=0 AREA=28229 VOLUME=253760
      SPACE-CONDITIONS=COND23N ..

    EW23N-N1=E-W  CONS=CONSWINDOW S-F-F=0.5 X=227 Y=50 Z=0
      AZ=0 TILT=90 H=18.4 W=227  G-F-F=0.5
    WIN23N-N1=WINDOW  G-T=GLAZING X=0 Y=3.38  H=10.4 W=227
      S-F-F=0.50 CONDUCT-SCHEDULE=DRAPESCHED  G-F-F=0.5

    EW23N-S1=E-W  LIKE=EW23N-N1 EXCEPT X=0 Y=0 AZ=180
    WIN23N-S1=WINDOW LIKE=WIN23N-N1 EXCEPT S-F-F=0.28
       G-F-F=0.72 ..

    ROOF23N=ROOF  CONS=CONSROOF56W S-F-F=0.7 X=0 Y=0 Z=19.4
      AZ=180 TILT=0 H=50 W=227  G-F-F=0.3 ..

    FLOOR23N=E-W  CONS=CONSFLOR56W S-F-F=0 X=0 Y=50 Z=0
      AZ=180 TILT=180 H=50 W=95.2  G-F-F=1.0

    EW23N-N2=E-W  CONS=CONSWINDOW S-F-F=0.1 X=214.6 Y=41.3 Z=11
      AZ=0 TILT=90 H=11 W=202.2 G-F-F=0.9
    WIN23N-N2=WINDOW  G-T=GLAZING X=0 Y=2.5 H=6 W=202.2 S-F-F=0.1
      CONDUCT-SCHEDULE=DRAPESCHED G-F-F=0.9 ..

    EW23N-S2=E-W  LIKE=EW23N-N2 EXCEPT X=12.4 Y=8.7 AZ=180
    WIN23N-S2=WINDOW LIKE=WIN23N-N2

    EW23N-E2=E-W LIKE=EW23N-N2 EXCEPT Y=8.7 AZ=90 W=32.6
    WIN23N-E2=WINDOW LIKE=WIN23N-N2 EXCEPT W=32.6 ..

    EW23N-W2=E-W LIKE=EW23N-E2 EXCEPT X=12.4 Y=41.3 AZ=270
    WIN23N-W2=WINDOW LIKE=WIN23N-E2

    FLOOR23N2=U-F AREA=5529 CONS=CONSUGW
*WARNING************* --- ********************************************************MISSING TERMINATOR FOR PREVIOUS COMMAND

    IW23N-23E=I-W
      AREA=920 CONSTRUCTION=IWALL NEXT-TO=ZONE23E
    IW23N-23W=I-W
      AREA=920 CONSTRUCTION=IWALL NEXT-TO=ZONE23W

            $  FOURTH FLOOR  $
```

```
ZONE4=SPACE
   X=0 Y=0 Z=21.0 AZ=0 AREA=27217 VOLUME=408255
   SPACE-CONDITIONS=COND4

EW4-N1=E-W
   CONSTRUCTION=CONSEWINDOW S-F-F=0.25 X=781 Y=295.9 Z=0
   AZ=0 TILT=90 H=14 W=731 G-F-F=0.25
WIN4-N1=WINDOW
   G-T=GLAZING1 X=0 Y=2.57 H=10 W=731 S-F-F=0.25
      G-F-F=0.75

EW4-S1=E-W LIKE=EW4-N1 EXCEPT X=50 Y=206.2 AZ=180
WIN4-S1=WINDOW LIKE=WIN4-N1

EW4-W1=E-W LIKE=EW4-N1 EXCEPT X=50 AZ=270 W=29.7
WIN4-W1=WINDOW LIKE=WIN4-N1 EXCEPT W=29.7

EW4-E1=E-W LIKE=EW4-W1 EXCEPT X=781 Y=206.2 AZ=90
WIN4-E1=WINDOW LIKE=WIN4-W1

EW4-N2=E-W LIKE=EW4-N1 EXCEPT X=39.9 Y=153.8 W=29.7
WIN4-N2=WINDOW LIKE=WIN4-W1

EW4-S2=E-W LIKE=EW4-N2 EXCEPT X=10.2 Y=50 AZ=180
WIN4-S2=WINDOW LIKE=WIN4-N2

EW4-W2=E-W LIKE=EW4-W1 EXCEPT X=10.2 Y=153.8 W=103.8
WIN4-W2=WINDOW LIKE=WIN4-W1 EXCEPT W=103.8

EW4-E2=E-W LIKE=EW4-W2 EXCEPT X=39.9 Y=50 AZ=90
WIN4-E2=WINDOW LIKE=WIN4-W2

EW4-N3=E-W LIKE=EW4-N1 EXCEPT X=1255.5 W=197.5
WIN4-N3=WINDOW LIKE=WIN4-N2 EXCEPT W=197.5

EW4-S3=E-W LIKE=EW4-N3 EXCEPT X=1058 AZ=180 Y=206.2
WIN4-S3=WINDOW LIKE=WIN4-N3

EW4-W3=E-W LIKE=EW4-W1 EXCEPT X=1058
WIN4-W3=WINDOW LIKE=WIN4-W1

EW4-E3=E-W LIKE=EW4-E1 EXCEPT X=1255.5
WIN4-E3=WINDOW LIKE=WIN4-E1

EW4-N4=E-W LIKE=EW4-N3 EXCEPT X=1047.9 Y=196 W=29.7
WIN4-N4=WINDOW LIKE=WIN4-W3

EW4-S4=E-W LIKE=EW4-N4 EXCEPT X=1018.2 Y=50 AZ=180
WIN4-S4=WINDOW LIKE=WIN4-N4

EW4-W4=E-W LIKE=EW4-W3 EXCEPT X=1018.2 Y=196 W=146
WIN4-W4=WINDOW LIKE=WIN4-W3 EXCEPT W=146

EW4-E4=E-W LIKE=EW4-W4 EXCEPT X=1047.9 Y=50 AZ=90
WIN4-E4=WINDOW LIKE=WIN4-W4

EW4-N5=E-W LIKE=EW4-N4 EXCEPT X=1327.9
WIN4-N5=WINDOW LIKE=WIN4-N4

EW4-S5=E-W LIKE=EW4-S4 EXCEPT X=1298.2
WIN4-S5=WINDOW LIKE=WIN4-S4
```

```
   EW4-W5-E-W LIKE-EW4-W4 EXCEPT Y=1298.2
   WIN4-W5-WINDOW LIKE-WIN4-W4

   EW4-E5-E-W LIKE-EW4-E4 EXCEPT Y=1327.9
   WIN4-E5-WINDOW LIKE=WIN4-E4

   IW4-23W-I-W
     AREA-16647  CONSTRUCTION-IWALL  NEXT-TO-ZONE23W

   IW4-56W-I-W
     AREA-16647  CONSTRUCTION=IWALL  NEXT-TO-ZONE56W

   IW4-23E-I-W
     AREA-10570  CONSTRUCTION=IWALL  NEXT-TO=ZONE23E

   IW4-56E-I-W
     AREA-10570  CONSTRUCTION-IWALL  NEXT-TO=ZONE56E

          $ REPORTS $
   LOADS-REPORT
     VERIFICATION-(ALL-VERIFICATION)
     SUMMARY-(ALL-SUMMARY) ..

   LDS-GLOB-REPORT-BLOCK
     VARIABLE-TYPE-GLOBAL
     VARIABLE-LIST-(3.4.13.16) ..

   LDS-ZONE56W-REPORT-BLOCK
     VARIABLE-TYPE-ZONE56W
     VARIABLE-LIST=(18.19.20.33.37.42.44)

   LDS-ZONE56E=REPORT-BLOCK
     VARIABLE-TYPE-ZONE56E
     VARIABLE-LIST-(18.19.20.33.37.42.44)

   LDS-PRT-HOURLY-REPORT
     REPORT-SCHEDULE-PRINTSCHED
     REPORT-BLOCK-(LDS-GLOB.LDS-ZONE56W.LDS-ZONE56E)

 END
 COMPUTE LOADS ..
 SAVE-FILES ..
 STOP ..
```

[illegible] DATA

[illegible]

```
[illegible]                         [illegible]
[illegible]                         [illegible]

[illegible]
                    [illegible]

                         * [illegible] *

[illegible]      [illegible]      [illegible]
                                  [illegible]
                                  [illegible]

[illegible]      [illegible]      [illegible]
                                  [illegible]
                                  [illegible]

[illegible]      [illegible]      [illegible]
                                  [illegible]
                                  [illegible]

[illegible]      [illegible]      [illegible]
                                  [illegible]
                                  [illegible]

[illegible]      [illegible]      [illegible]
                                  [illegible]
                                  [illegible]

[illegible]      [illegible]      [illegible]

[illegible]      [illegible]      [illegible]
[illegible]      [illegible]      [illegible]
                                  OUTSIDE [illegible] OUTSIDE [illegible]

[illegible]      [illegible]      [illegible]
                                  [illegible]
                                  [illegible]
                                  [illegible]
                                  [illegible]

                         * ZONE [illegible] *

ZONE [illegible]   [illegible]     [illegible]
                                  [illegible]
                                  [illegible]
                                  [illegible]
                                  [illegible]
                                  [illegible]
                                  [illegible]

ZONE [illegible]   [illegible]     [illegible]
                                  [illegible]
                                  [illegible]
                                  [illegible]
```

```
                                  [illegible] CFM [illegible]
                                  BASEBOARD RATING= -69130(?)
                                  EXHAUST CFM=[illegible]

ZONE2[illegible]  =ZONE           LIKE ZONE[illegible] EXCEPT
                                  ASSIGNED CFM=[illegible]
                                  BASEBOARD RATING= -32530(?)
                                  EXHAUST CFM=[illegible]

ZONE23N-ZONE                      LIKE ZONE5OW EXCEPT
                                  ASSIGNED CFM=[illegible]
                                  BASEBOARD RATING= -17250(?)
                                  EXHAUST CFM=[illegible]

                                $ [illegible] SYSTEM DESCRIPTION $

CENTRAL      =SYSTEM              SYSTEM-TYPE=[illegible]
                                  ZONE-NAMES=(ZONE5OW,ZONE[illegible],ZONE23W,
                                  ZONE23E,ZONE23N)
                                  SUPPLY-CFM=[illegible]
                                  [illegible]
                                  MIN-OUTSIDE-AIR=[illegible]
                                  MAX-SUPPLY-T=[illegible]
                                  HEAT-[illegible]
                                  HEATING-[illegible]
                                  BASEBOARD-[illegible]
                                  [illegible]
                                  [illegible]

                                $ ZONE DESCRIPTION $

ZONE4        =ZONE                ASSIGNED-CFM=[illegible]
                                  [illegible] DESIGN [illegible] 72
                                  HEAT-TEMP-SCH=[illegible] THERM1(?)

                                $ [illegible] SYSTEM DESCRIPTION $

A[illegible]  =SYSTEM             SYSTEM-TYPE=[illegible]
                                  ZONE-NAMES=(ZONE4)
                                  SUPPLY-CFM=[illegible]
                                  [illegible]
                                  MIN-OUTSIDE-AIR=[illegible]
                                  MAX-SUPPLY-T=[illegible]
                                  HEAT-[illegible]
                                  HEATING-[illegible]
                                  [illegible]
                                  [illegible]
                                  SUPPLY-[illegible] 12(?)

                                $ ZONE DESCRIPTION $

ZONE23S      =ZONE                ASSIGNED-CFM=[illegible]
                                  [illegible] DESIGN [illegible] 72
                                  HEAT-TEMP-[illegible]
                                  [illegible]
                                  [illegible]

                                $ [illegible] SYSTEM DESCRIPTION $

[illegible]  =SYSTEM              SYSTEM-TYPE=[illegible]
```

```
            ZONE-NAMES=(ZONE [illegible])
            [illegible]
            [illegible]
            [illegible]
            MIN-OUTSIDE-AIR [illegible]
            MAX-[illegible]
            MIN-[illegible]
            HEATING-SCHEDULE-FANS
            COOLING-SCHEDULE-[illegible]
            HEAT-SET-T-[illegible]
            [illegible]
            [illegible]
            [illegible]
            MOTOR-PLACEMENT=OUTSIDE-AIRFLOW
            SUPPLY-[illegible]
            SUPPLY-DELTA-T-[illegible]
            RETURN-[illegible]
            RETURN-DELTA-T-[illegible]
            OUTSIDE-FAN-[illegible]
            HEAT-SOURCE=HOT-WATER

CONSTANT-[illegible]-A    SYSTEM-NAME=(CENTRAL-ASSEMBLY-[illegible])

          $ HOURLY REPORTS $

[illegible]    =[illegible]    VARIABLE-TYPE=[illegible]
                               VARIABLE-LIST=([illegible])
[illegible]    =[illegible]    LIKE [illegible] EXCEPT VARIABLE-TYPE=[illegible]
[illegible]    =[illegible]    LIKE [illegible] EXCEPT VARIABLE-TYPE=[illegible]
[illegible]    =[illegible]    LIKE [illegible] EXCEPT VARIABLE-TYPE=[illegible]
[illegible]    =[illegible]    LIKE [illegible] EXCEPT VARIABLE-TYPE=[illegible]
Z[illegible]   =[illegible]    VARIABLE-TYPE=ZONE-A
                               VARIABLE-LIST=([illegible])
[illegible]    =[illegible]    VARIABLE-TYPE=ZONE-[illegible]
                               VARIABLE-LIST=([illegible] 12 [illegible])
[illegible]    =[illegible]    VARIABLE-TYPE=[illegible]
                               VARIABLE-LIST=([illegible])
[illegible]    =[illegible]    REPORT-SCHEDULE=[illegible]
                               REPORT-BLOCK=([illegible] GLOBE)
[illegible]    =[illegible]    VARIABLE-TYPE=[illegible]
                               VARIABLE-LIST=([illegible],10,12,21,26,[illegible])
[illegible]    =[illegible]    VARIABLE-TYPE=[illegible]
                               VARIABLE-LIST=([illegible],10,1[illegible],21,2[illegible])
[illegible]    =[illegible]    VARIABLE-TYPE=[illegible]
                               VARIABLE-LIST=([illegible],1,2,5,6,20,18,[illegible],41,60,[illegible])
[illegible]    =[illegible]    REPORT-SCHEDULE=[illegible]
                               REPORT-BLOCK=(CENT-ASSEM-[illegible])

END
COMPUTE SYSTEMS
INPUT [illegible]
```

P D L   P R O C E S S O R   I N P U T   D A T A

81/09/25   09.57.20   PDL RUN 1

```
CONVENTION=PLANT ASSIGNMENT
PLANT REPORT SUMMARY=(ALL SUMMARY)
CHILLER    =PLANT-EQUIPMENT
                          TYPE=OPEN-CENT-CHLR SIZE=-1.000

                        $ CENTRAL HEATING PLANT $

S-HTG      =LOAD-ASSIGNMENT
                          TYPE=HEATING
                          LOAD-RANGE=9999
                          PLANT-EQUIPMENT=UTILITY
                          NUMBER=999

           LOAD-MANAGEMENT
                          PREF-LOAD-RANGE=999
                          LOAD-ASSIGNMENT=(S-HTG,DEFAULT,DEFAULT)

           ENERGY-COST    RESOURCE=STEAM
                          UNIT=1000KWH

END
COMPUTE PLANT
STOP
```

L D L   P R O C E S S O R   I N P U T   D A T A

82/09/29.   08:40:25.   LDL RUN   1

```
DIAGNOSTIC CAUTIONS ..
ABORT ERRORS ..
$  BASELINE BUILDING  $
TITLE=LINE-1=*US AIR FORCE ACADEMY*
      LINE-2=*COLORADO SPRINGS*
      LINE-3=*FIELD HOUSE EC STUDY*
      LINE-4=*B. DAVIS/WX-4/LANL* ..
RUN-PERIOD JAN 1 1978 THRU DEC 31 1978 ..
BUILDING-LOCATION
      LATITUDE=39  LONGITUDE=105  ALTITUDE=7065
      TIME-ZONE=7  AZIMUTH=0 ..
BUILDING-SHADE
      HEIGHT=450  WIDTH=420  X=-12  Y=-12
      Z=59.9  AZ=180  TILT=0 ..
LAW1=LAYERS   MATERIAL=(CC25,IN23) ..
LAW2=LAYERS   MATERIAL=(CC07,IN23) ..
LAW3=LAYERS   MATERIAL=(CC07,GP03) ..
LAR1=LAYERS   MATERIAL=(RG01,BP01,BR01,IN75,IN22) ..
CW1=CONSTRUCTION   LA=LAW1  ABS=.65  RO=3 ..
CW2=CONSTRUCTION   LA=LAW2  ABS=.65  RO=3 ..
CW3=CONSTRUCTION   LA=LAW3  ABS=.65  RO=3 ..
CR1=CONSTRUCTION   LA=LAR1  ABS=.29  RO=1 ..
CUW=CONSTRUCTION   U=.10 ..
CUF=CONSTRUCTION   U=.10 ..
CIW1=CONSTRUCTION  U=.32 ..
CIW2=CONSTRUCTION  U=2.0 ..
GLT=GLASS-TYPE   PANES=1  G-T-C=7 ..
              $ LIGHTING SCHEDULE $
LS1=SCHEDULE THRU MAY 20 (ALL)(1,5)(.1)(6,21)(.9)(22,24)(.1)
             THRU SEP 1 (ALL)(1,5)(.1)(6,21)(.5)(22,24)(.1)
             THRU DEC 31 (ALL)(1,5)(.1)(6,21)(.9)(22,24)(.1) ..
              $ PEOPLE SCHEDULES $
$ BASKETBALL STADIUM $
WBS1=WEEK-SCHEDULE (MON,THU)(1,18)(0)(19,22)(.6)(23,24)(0)
                   (FRI)(1,24)(0)
                   (WEH)(1,24)(0) ..
WBS2=WEEK-SCHEDULE (MON)(1,24)(0)
                   (TUE,WED)(1,18)(0)(19,22)(.6)(23,24)(0)
                   (THU,FRI)(1,24)(0)
                   (WEH)(1,24)(0) ..
```

```
                 THRU NOV 1 WBS2
                 THRU DEC 31 WBS1 ..
$ HOCKEY ARENA $

WHS1=WEEK-SCHEDULE (MON,THU)(1,24)(0)
                   (FRI,SUN)(1,18)(0)(19,22)(.6)(23,24)(0)
                   (HOL)(1,24)(0) ..

WHS2=WEEK-SCHEDULE (MON,THU)(1,24)(0)
                   (FRI,SAT)(1,18)(0)(19,20)(.6)(21,24)(0)
                   (SUN,HOL)(1,24)(0) ..

HS1=SCHEDULE THRU FEB 20 WHS1
             THRU NOV 1 WHS2
             THRU DEC 31 WHS1 ..

$ MULTI-PURPOSE AREA $

WMPS1=WEEK-SCHEDULE (WD)(1,24)(0)
                    (WE)(1,12)(0)(13,18)(.6)(19,24)(0)
                    (HOL)(1,24)(0) ..

WMPS2=WEEK-SCHEDULE (WD)(1,24)(0)
                    (SAT)(1,12)(0)(13,16)(.6)(17,24)(0)
                    (SUN,HOL)(1,24)(0) ..

MPS1=SCHEDULE THRU FEB 20 WMPS1
              THRU NOV 1 WMPS2
              THRU DEC 31 WMPS1 ..

            $ SOURCE SCHEDULE - HOCKEY $

RINK1=SCHEDULE THRU DEC 31 (ALL) (1,24) (1) ..


            $ SPACE CONDITIONS $

SCBBALL=SPACE-CONDITIONS
        T=(68)  P-SCH=BS1  N-O-P=6000  P-H-G=450
        L-SCH=LS1  L-T=INCAND  L-KW=107.42
        I-M=AIR-CHANGE  A-C=.58  Z-TYPE=CONDITIONED ..

SCHOCKEY=SPACE-CONDITIONS
         T=(68)  P-SCH=HS1  N-O-P=4400  P-H-G=450
         L-SCH=LS1  L-T=INCAND  L-KW=74.4
         SOURCE-SCHEDULE=RINK1  SOURCE-BTU/HR=-154700
         I-M=AIR-CHANGE  A-C=.58  Z-TYPE=CONDITIONED ..

SCMP=SPACE-CONDITIONS
     T=(68)  P-SCH=MPS1  N-O-P=1200  P-H-G=450
     L-SCH=LS1  L-T=INCAND  L-KW=137.52
     I-M=AIR-CHANGE  A-C=.58  Z-TYPE=CONDITIONED ..

            $ BASKETBALL STADIUM - WALLS,ROOF,FLOOR $

DIAGNOSTIC NO-LIMITS ..

BASKETBALL=SPACE
           X=0  Y=0  Z=0  AZIMUTH=0  AREA=47124
           VOLUME=2780316  SPACE-CONDITIONS=SCBBALL ..
-CAUTION------------------- ======= ------------------------------------------------
-CAUTION--- VALUE GREATER THAN MAXIMUM OF      .1000E+07
```

```
B-SW1=EXTERIOR-WALL
      CONSTRUCTION=CW3  X=0  Y=0  Z=0  HEIGHT=13.2
      WIDTH=198  AZIMUTH=180  TILT=90 ..

B-SW2=EXTERIOR-WALL
      CONSTRUCTION=CW1  X=0  Y=0  Z=13.2  HEIGHT=38.8
      WIDTH=198  AZIMUTH=180  TILT=90 ..

   B-SG1=WINDOW
         GLASS-TYPE=GLT  X=0  Y=0
         HEIGHT=7.35  WIDTH=158 ..

   B-SG2=WINDOW
         GLASS-TYPE=GLT  X=158  Y=0
         HEIGHT=38.8  WIDTH=40 ..

B-SW3=EXTERIOR-WALL
      CONSTRUCTION=CW1  X=0  Y=0  Z=52.0  HEIGHT=8
      WIDTH=198  AZIMUTH=180  TILT=90 ..

B-WW1=EXTERIOR-WALL
      CONSTRUCTION=CW3  X=0  Y=238  Z=0  HEIGHT=13.2
      WIDTH=238  AZIMUTH=270  TILT=90 ..

B-WW2=EXTERIOR-WALL
      CONSTRUCTION=CW1  X=C  Y=238  Z=13.2  HEIGHT=38.8
      WIDTH=238  AZIMUTH=270  TILT=90 ..

B-WW3=EXTERIOR-WALL
      CONSTRUCTION=CW1  X=0  Y=238  Z=52.0  HEIGHT=8
      WIDTH=238  AZIMUTH=270  TILT=90 ..

B-R1=ROOF
     CONSTRUCTION=CR1  X=0  Y=0  Z=60.0  HEIGHT=238
     WIDTH=198  AZIMUTH=180  TILT=0 ..

B-U1=UNDERGROUND-FLOOR
     AREA=47124  CONSTRUCTION=CUF ..

            $ HOCKEY ARENA - WALLS,ROOF,FLOOR $

HOCKEY=SPACE
       X=198  Y=0  Z=0  AZIMUTH=0  AREA=47124
       VOLUME=2780316  SPACE-CONDITIONS=SCHOCKEY ..
-CAUTION--------------- ******* ------------------------------------------------------
-CAUTION--- VALUE GREATER THAN MAXIMUM OF      .1000E+07

H-SW1=EXTERIOR-WALL
      CONSTRUCTION=CW3  X=0  Y=0  Z=0  HEIGHT=13.2
      WIDTH=198  AZIMUTH=180  TILT=90 ..

H-SW2=EXTERIOR-WALL
      CONSTRUCTION=CW1  X=0  Y=0  Z=13.2  HEIGHT=38.8
      WIDTH=198  AZIMUTH=180  TILT=90 ..

   H-SG1=WINDOW
         GLASS-TYPE=GLT  X=0  Y=0
         HEIGHT=38.8  WIDTH=40 ..

   H-SG2=WINDOW
         GLASS-TYPE=GLT  X=40 Y=0
         HEIGHT=7.35  WIDTH=158 ..
```

```
        CONSTRUCTION=CW1  X=0  Y=0  Z=52.0  HEIGHT=8
        WIDTH=198  AZIMUTH=180  TILT=90 ..

 H-EW1=EXTERIOR-WALL
        CONSTRUCTION=CW3  X=198  Y=0  Z=0  HEIGHT=13.2
        WIDTH=238  AZIMUTH=90  TILT=90 ..

 H-EW2=EXTERIOR-WALL
        CONSTRUCTION=CW1  X=198  Y=0  Z=13.2  HEIGHT=38.8
        WIDTH=238  AZIMUTH=90  TILT=90 ..

 H-EW3=EXTERIOR-WALL
        CONSTRUCTION=CW1  X=198  Y=0  Z=52.0  HEIGHT=8
        WIDTH=238  AZIMUTH=90  TILT=90 ..

 H-R1=ROOF
       CONSTRUCTION=CR1  X=0  Y=0  Z=60.0  HEIGHT=238
       WIDTH=198  AZIMUTH=180  TILT=0 ..

 H-U1=UNDERGROUND-FLOOR
       AREA=47124  CONSTRUCTION=CUF ..

 H-IW1=INTERIOR-WALL
        AREA=11140  CONSTRUCTION=CIW2  NEXT-TO=BASKETBALL ..

                $ MULTI-PURPOSE AREA - WALLS,ROOF,FLOOR $

 MULTI-PURPOSE=SPACE
                   X=0  Y=238  Z=0  AZIMUTH=0  AREA=74448
                   VOLUME=5732496  SPACE-CONDITIONS=SCMP ..
-CAUTION-------------------- - ======= ------------------------------------------------
-CAUTION--- VALUE GREATER THAN MAXIMUM OF      .1000E+07

 MP-NW1=EXTERIOR-WALL
         CONSTRUCTION=CW2  X=396  Y=188  Z=0  HEIGHT=13.2
         WIDTH=396  AZIMUTH=0  TILT=90 ..

 MP-NW2=EXTERIOR-WALL
         CONSTRUCTION=CW1  X=396  Y=188  Z=13.2  HEIGHT=38.8
         WIDTH=396  AZIMUTH=0  TILT=90 ..

 MP-NW3=EXTERIOR-WALL
         CONSTRUCTION=CW1  X=396  Y=188  Z=52.0  HEIGHT=8
         WIDTH=396  AZIMUTH=0  TILT=90 ..

 MP-WW1=EXTERIOR-WALL
         CONSTRUCTION=CW2  X=0  Y=188  Z=0  HEIGHT=13.2
         WIDTH=188  AZIMUTH=270  TILT=90 ..

 MP-WW2=EXTERIOR-WALL
         CONSTRUCTION=CW1  X=0  Y=188  Z=13.2  HEIGHT=38.8
         WIDTH=188  AZIMUTH=270  TILT=90 ..

 MP-WW3=EXTERIOR-WALL
         CONSTRUCTION=CW1  X=0  Y=188  Z=52.0  HEIGHT=8
         WIDTH=188  AZIMUTH=270  TILT=90 ..

 MP-EW1=EXTERIOR-WALL
         CONSTRUCTION=CW2  X=396  Y=0  Z=0  HEIGHT=13.2
         WIDTH=188  AZIMUTH=90  TILT=90 ..

 MP-EW2=EXTERIOR-WALL
         CONSTRUCTION=CW1  X=396  Y=0  Z=13.2  HEIGHT=38.8
```

```
          WIDTH=188  AZIMUTH=90  TILT=90 ..

MP-EW3=EXTERIOR-WALL
          CONSTRUCTION=CW1  X=396  Y=0  Z=52.0  HEIGHT=8
          WIDTH=188  AZIMUTH=90  TILT=90 ..

MP-R1=ROOF
         CONSTRUCTION=CR1  X=0  Y=0  Z=60.0  HEIGHT=188
         WIDTH=396  AZIMUTH=180  TILT=0 ..

MP-U1=UNDERGROUND-FLOOR
         AREA=74448  CONSTRUCTION=CUF ..

MP-IW1=INTERIOR-WALL
          AREA=11880  CONSTRUCTION=CIW1  NEXT-TO=BASKETBALL ..

MP-IW2=INTERIOR-WALL
          AREA=11880  CONSTRUCTION=CIW1  NEXT-TO=HOCKEY ..

LOADS-REPORT
         VERIFICATION=(ALL-VERIFICATION)
         SUMMARY=(ALL-SUMMARY) ..

HW1=SCHEDULE THRU DEC 31 (ALL)(1,24)(1) ..

BUILDING-RESOURCE
         HW-SCHEDULE=HW1  HOT-WATER=65000 ..


END ..
```

```
COMPUTE LOADS ..


INPUT SYSTEMS ..
```

```

             $ SCHEDULES $

BB-HB=SCHEDULE THRU DEC 31 (ALL) (1,24) (70) ..


BB-MASW1=WEEK-SCHEDULE (MON,THU)(1,18)(0)(19,22)(1)(23,24)(0)
                       (FRI)(1,24)(0)
                       (WEH)(1,24)(0) ..

BB-MASW2=WEEK-SCHEDULE (MON)(1,24)(0)
                       (TUE,WED)(1,18)(0)(19,22)(1)(23,24)(0)
                       (THU,FRI)(1,24)(0)
                       (WEH)(1,24)(0) ..

BB-MAS=SCHEDULE THRU FEB 20 BB-MASW1
                THRU NOV 1 BB-MASW2
                THRU DEC 31 BB-MASW1 ..


H-HTS=SCHEDULE THRU DEC 31 (ALL)(1,24)(62) ..


H-MASW1=WEEK-SCHEDULE (MON,THU)(1,24)(0)
                      (FRI,SUN)(1,18)(0)(19,22)(1)(23,24)(0)
                      (HOL)(1,24)(0) ..

H-MASW2=WEEK-SCHEDULE (MON,THU)(1,24)(0)
                      (FRI,SAT)(1,18)(0)(19,20)(1)(21,24)(0)
                      (SUN,HOL)(1,24)(0) ..

H-MAS=SCHEDULE THRU FEB 20 H-MASW1
               THRU NOV 1 H-MASW2
               THRU DEC 31 H-MASW1 ..


MP-HTS=SCHEDULE THRU DEC 31 (ALL)(1,24)(65) ..

MP-MASW1=WEEK-SCHEDULE (WD)(1,24)(0)
                       (WE)(1,12)(0)(13,18)(1)(19,24)(0)
                       (HOL)(1,24)(0) ..

MP-MASW2=WEEK-SCHEDULE (WD)(1,24)(0)
                       (SAT)(1,12)(0)(13,16)(1)(17,24)(0)
                       (SUN,HOL)(1,24)(0) ..

MP-MAS=SCHEDULE THRU FEB 20 MP-MASW1
                THRU NOV 1 MP-MASW2
                THRU DEC 31 MP-MASW1 ..


HOT-DAY1=DAY-RESET-SCH
         SUPPLY-HI=120  SUPPLY-LO=60
         OUTSIDE-HI=70  OUTSIDE-LO=0 ..
HOT-RESET1=RESET-SCHEDULE THRU DEC 31 (ALL) HOT-DAY1 ..
```

```
COOL-SCH1=SCHEDULE THRU DEC 31 (ALL)(1,24)(0) ..

         $ BASKETBALL AREA $

BASKETBALL=ZONE
          DESIGN-HEAT-T=70  HEAT-TEMP-SCH=BB-HB
          DESIGN-COOL-T=80  ZONE-TYPE=CONDITIONED ..

BB-CONTROL=SYSTEM-CONTROL
          MAX-SUPPLY-T=120  MIN-SUPPLY-T=60
         COOLING-SCHEDULE=COOL-SCH1
          HEAT-CONTROL=RESET  HEAT-RESET-SCH=HOT-RESET1
          COOL-SET-T=60  ECONO-LIMIT-T=75 ..

BB-AIR=SYSTEM-AIR
      MIN-AIR-SCH=BB-MAS  OA-CONTROL=TEMP ..

BB-FANS=SYSTEM-FANS
      FAN-SCHEDULE=BB-MAS  FAN-CONTROL=SPEED
      SUPPLY-KW=.00032
      NIGHT-CYCLE-CTRL=CYCLE-ON-ANY ..

BB-SYS=SYSTEM
      SYSTEM-TYPE=MZS  ZONE-NAMES=(BASKETBALL)
      SYSTEM-CONTROL=BB-CONTROL  SYSTEM-AIR=BB-AIR
      SYSTEM-FANS=BB-FANS ..

         $ HOCKEY ARENA $

HOCKEY=ZONE
      DESIGN-HEAT-T=62  HEAT-TEMP-SCH=H-HTS
      DESIGN-COOL-T=80  ZONE-TYPE=CONDITIONED ..

H-CONTROL=SYSTEM-CONTROL
         MAX-SUPPLY-T=120  MIN-SUPPLY-T=60
         HEAT-CONTROL=RESET  HEAT-RESET-SCH=HOT-RESET1
         COOLING-SCHEDULE=COOL-SCH1
         COOL-SET-T=40  ECONO-LIMIT-T=75
-CAUTION-------------------------- ** ----------------------------------------------------
-CAUTION---VALUE NOT BETWEEN        45.0000 AND        70.0000

H-AIR=SYSTEM-AIR
     MIN-AIR-SCH=H-MAS  OA-CONTROL=TEMP ..

H-FANS=SYSTEM-FANS
      FAN-SCHEDULE=H-MAS  FAN-CONTROL=SPEED
      SUPPLY-KW=.00032
      NIGHT-CYCLE-CTRL=CYCLE-ON-ANY ..

H-SYS=SYSTEM
     SYSTEM-TYPE=MZS  ZONE-NAMES=(HOCKEY)
     SYSTEM-CONTROL=H-CONTROL  SYSTEM-AIR=H-AIR
     SYSTEM-FANS=H-FANS ..

         $ MULTI-PURPOSE AREA $

MULTI-PURPOSE=ZONE
            DESIGN-HEAT-T=65  HEAT-TEMP-SCH=MP-HTS
            DESIGN-COOL-T=80  ZONE-TYPE=CONDITIONED ..

MP-CONTROL=SYSTEM-CONTROL
          MAX-SUPPLY-T=120  MIN-SUPPLY-T=60
          HEAT-CONTROL=RESET  HEAT-RESET-SCH=HOT-RESET1
```

```
               COOLING-SCHEDULE=COOL-SCH1
               COOL-SET-T=60  ECONO-LIMIT-T

MP-AIR=SYSTEM-AIR
         MIN-AIR-SCH=MP-MAS  OA-CONTROL=TEMP ..

MP-FANS=SYSTEM-FANS
          FAN-SCHEDULE=MP-MAS  FAN-CONTROL=SPEED
          SUPPLY-KW=.00032
          NIGHT-CYCLE-CTRL=CYCLE-ON-ANY

MP-SYS=SYSTEM
         SYSTEM-TYPE=MZS  ZONE-NAMES=(MULTI-PURPOSE)
         SYSTEM-CONTROL=MP-CONTROL  SYSTEM-AIR=MP-AIR
         SYSTEM-FANS=MP-FANS ..

PA1=PLANT-ASSIGNMENT
     SYSTEM-NAMES=(BB-SYS,H-SYS,MP-SYS) ..

SYSTEMS-REPORT
        SUMMARY=(SS-A) ..

$ RS1=SCHEDULE THRU FEB 1 (ALL) (1,24) (0)
                $ THRU MAR 15 (ALL) (1,24) (1)
                $ THRU DEC 31 (ALL) (1,24) (0) ..

$ RB1=REPORT-BLOCK
     $ VARIABLE-TYPE=BASKETBALL
     $ VARIABLE-LIST=(6,7,9,11,12,14,17,20)

$ RB2=REPORT-BLOCK
     $ VARIABLE-TYPE=BB-SYS
     $ VARIABLE-LIST=(1,3,4,5,17,18,20,21,33) ..

$ HR1=HOURLY-REPORT
     $ REPORT-SCHEDULE=RS1  REPORT-BLOCK=(RB1,RB2)

END ..
COMPUTE SYSTEMS ..

INPUT PLANT ..
```

P D L   P R O C E S S O R   I N P U T   D A T A

82/09/29.   08:40:25.   PDL RUN 1

```
* PARAMETER  CAREA=3000 ..
$ PARAMETER  CFLOW=60  ..
$ PARAMETER  TVOL=5400 ..


CHILLER1 = PLANT-EQUIPMENT
         TYPE=OPEN-CENT-CHLR   SIZE=0.600 ..

$  HEAT-RECOVERY
      $  SUPPLY-1=(SOL-PROCESS-HEAT)
      $  DEMAND-1=(PROCESS-HEAT) ..


LA1=LOAD-ASSIGNMENT
    TYPE=HEATING
    LOAD-RANGE=999
        PLANT-EQUIPMENT=UTILITY
        NUMBER=999 ..

LOAD-MANAGEMENT
      PRED-LOAD-RANGE=999
      LOAD-ASSIGNMENT=(LA1,DEFAULT,DEFAULT)

PLANT-REPORT
      VERIFICATION=(PV-A)
      SUMMARY=(PS-A,PS-B,PS-D,BEPS) ..


ENERGY-COST   RESOURCE=STEAM  UNIT=1000000 ..

$ SOLAR-EQUIPMENT ..

$ SYSTEM TYPE=CLSH ..


$ INSOL=COMPONENT
      $    TILT=44  AZIMUTH=180.0 ..

$ SUBSYS=COMPONENT
       $  COL-AREA=CAREA  EFF-COEF=(.705,-.887)  ANGLE-COEF=-0.1
       $  COL-FLOW=CFLOW  PUMP-KW=15  TANK-VOL=TVOL  LOAD-FLOW=(0,0,0)


END ..
*WARNING***********************************************************NO HEATING EQUIPMENT HAS BEEN DEFINED
-CAUTION-----------------------------------------------------------NO COOLING TOWER DEFINED, DEFAULT USED
COMPUTE PLANT ..
STOP ..
```

L D L   P R O C E S S O R   I N P U T   D A T A

82/10/17.   15:32:31.   LDL RUN 1

```
TITLE        LINE-1 *AIR FORCE ACADEMY*
             LINE-2 *AERONAUTICS LABORATORY*
             LINE-3 *LOS ALAMOS NATIONAL LAB*
             LINE-4 *ADJUSTED BASELINE* ..

ABORT        ERRORS ..

DIAGNOSTIC ERRORS ..

RUN-PERIOD JAN 1 1964 THRU DEC 31 1964 ..

             $*****  SCHEDULES *****$

PEOPLE-LIGHTS = SCHEDULE
             THRU DEC 31 (WD) (1,7) (.1)
                              (8,17) (1)
                              (18,24) (.1)
                        (WEH) (1,24) (.1) ..

INFILTRATION = SCHEDULE
                 THRU DEC 31 (WD)  (1,7)  (1)
                                   (8,17)(.1)
                                   (18,24)(1)
                             (WEH)(1,24)(1) ..

FIVE-HOURS=SCHEDULE
              THRU DEC 31 (WD) (1,9) (0)
                               (10,15) (1)
                               (16,24) (0)
                         (WEH)(1,24)(0) ..
BUILDING-LOCATION
                LATITUDE = 39
                LONGITUDE = 105
                ALTITUDE = 7100
                TIME-ZONE = 7 ..

              $********* LAYERS    *******$

EXT-WALL-1 = LAYERS
                MATERIAL = (CC33,AL21,CB26,AL21,CB26,GP03)
                THICKNESS = (.1667,.125,.5,.1667,.5,.0625) ..

ROOF-LAYERS = LAYERS
                MATERIAL = (BR01,IN74,CC33,AC03,AL33,GP03)
                THICKNESS = (.0313,.1667,.1667,.0625,.333,.0625) ..

CONCRETE = LAYERS
                 MATERIAL = (CC07)
                 THICKNESS = (1.0) ..

UN-ROOF-LAYERS = LAYERS
                 MATERIAL = (CC33,BR02,CC07)
                 THICKNESS = (.25,.0025,1.0) .

BLOCK-LAYERS = LAYERS
```

```
                        MATERIAL = (CB26,GP03)
                        THICKNESS = (.5,.0625) ..
TCCR-LAYERS = LAYERS
                        MATERIAL = (CC07,AL21,CC03,IN23)
                        THICKNESS = (1.0,.25,.3333,.1667) ..

STEEL-DOOR = LAYERS
                        MATERIAL = (IN01)
                        THICKNESS = (.09) ..

STEEL-DOORS = LAYERS
                        MATERIAL = (AL21)
                        THICKNESS = (.0833) ..
 WALL HAS NO HEAT CAPACITY.  U-VALUE WILL BE CALCULATED AND USED.

                 $*******     CONSTRUCTIONS    *******$

PRE-CAST-CONCRETE = CONSTRUCTION
                        LAYERS = EXT-WALL-1
                        ABSORPTANCE = .55
                        ROUGHNESS = 1 ..

ROOF-CONS = CONSTRUCTION
                        LAYERS = ROOF-LAYERS
                        ABSORPTANCE = .5
                        ROUGHNESS = 1 ..

UNDERGROUND-ROOF = CONSTRUCTION
                        LAYERS = UN-ROOF-LAYERS ..

CONCRETE-FLOOR = CONSTRUCTION
                        LAYERS = CONCRETE ..

POURED-CONCRETE = CONSTRUCTION
                        LAYERS = ASHW-40 ..

CONCRETE-BLOCK = CONSTRUCTION
                        LAYERS = BLOCK-LAYERS ..

NO-WALL = CONSTRUCTION
                        U-VALUE = 10 ..

TCCR-WALL = CONSTRUCTION
                        LAYERS = TCCR-LAYERS ..

STEEL-PANEL-DOOR = CONSTRUCTION
                        LAYERS = STEEL-DOOR
                        ABSORPTANCE = .8
                        ROUGHNESS = 5 ..

ROLL-UP-DOOR = CONSTRUCTION
                        LAYERS = STEEL-DOORS
                        ABSORPTANCE = .8
                        ROUGHNESS = 5 ..

GLASS-DOOR = GLASS-TYPE
                        PANES = 1
                        GLASS-TYPE-CODE = 10 ..

               $********    SPACES - FIRST FLOOR     ********$

CONDITIONS = SPACE-CONDITIONS
                          PEOPLE-SCHEDULE = PEOPLE-LIGHTS
                          PEOPLE-HG-LAT = 200
```

```
                    PEOPLE-HG-SENS = 250
                    LIGHTING-SCHEDULE = PEOPLE-LIGHTS
                    FLOOR-WEIGHT = 0
                    INF-METHOD = AIR-CHANGE
                    AIR-CHANGES/HR = .5
                    INF-SCHEDULE = INFILTRATION ..

TRISONIC = SPACE
                   X=153.78      Y=0      Z=15
                   SHAPE = BOX
                   HEIGHT = 19.5   WIDTH = 69.9   DEPTH = 41.88
                   SPACE-CONDITIONS = CONDITIONS
                   NUMBER-OF-PEOPLE = 6
                   LIGHTING-KW = 7.2 ..

                   TRISONIC-FLOOR = INTERIOR-WALL
                         HEIGHT = 41.88
                         WIDTH = 69.9
                         LOCATION = BOTTOM
                         CONSTRUCTION = CONCRETE-FLOOR
                         NEXT-TO = MECHANICAL ..

                    TRISONIC-NORTH = EXTERIOR-WALL
                          CONSTRUCTION = PRE-CAST-CONCRETE
                          HEIGHT = 19.5
                          WIDTH = 69.9
                          LOCATION = BACK

                    TRISONIC-SOUTH = EXTERIOR-WALL
                          LIKE = TRISONIC-NORTH
                          LOCATION = FRONT ..

                    TRISONIC-EAST = EXTERIOR-WALL
                          CONSTRUCTION = PRE-CAST-CONCRETE
                          HEIGHT = 19.5  WIDTH = 41.88
                          LOCATION = RIGHT ..

                    TRISONIC-ROOF = ROOF
                          CONSTRUCTION = ROOF-CONS
                          HEIGHT = 41.88  WIDTH = 69.9
                          LOCATION = TOP ..


COMBUSTION = SPACE
                    X = 111.88    Y=0     Z=15
                    SHAPE = BOX
                    HEIGHT = 19.5
                    WIDTH = 41.94
                    DEPTH = 36.0
                    SPACE-CONDITIONS = CONDITIONS
                    NUMBER-OF-PEOPLE = 10
                    LIGHTING-KW = 2.0 ..

                    COMBUSTION-EAST = INTERIOR-WALL
                          HEIGHT = 19.5   WIDTH = 36
                          LOCATION = RIGHT
                          CONSTRUCTION = CONCRETE-BLOCK
                          NEXT-TO = TRISONIC ..

                    COMBUSTION-WEST = INTERIOR-WALL
                          HEIGHT = 19.5
                          WIDTH = 36.0
                          LOCATION = LEFT
                          CONSTRUCTION = CONCRETE-BLOCK
```

```
                    NEXT-TO = LOBBY-1 ..

                COMBUSTION-SOUTH = EXTERIOR-WALL
                    CONSTRUCTION = PRE-CAST-CONCRETE
                    HEIGHT = 19.5   WIDTH = 41.94
                    LOCATION = FRONT ..

               COMBUSTION-NORTH = INTERIOR-WALL
                    HEIGHT = 19.5  WIDTH = 41.94
                    LOCATION = BACK
                    CONSTRUCTION = CONCRETE-BLOCK
                    NEXT-TO = NORTH-LOBBY ..

               COMBUSTION-FLOOR = INTERIOR-WALL
                    HEIGHT = 36   WIDTH = 41.94
                    LOCATION = BOTTOM
                    CONSTRUCTION = CONCRETE-FLOOR
                    NEXT-TO = SHOP ..

               COMBUSTION-ROOF = ROOF
                    CONSTRUCTION = ROOF-CONS
                    HEIGHT = 36   WIDTH = 41.94
                    LOCATION = TOP ..


NORTH-LOBBY = SPACE
                X=83.88   Y=36  Z=15
                SHAPE = BOX
                HEIGHT = 19.5   WIDTH = 69.9  DEPTH = 5.88
                SPACE-CONDITIONS = CONDITIONS
                LIGHTING-TYPE = INCAND
                LIGHTING-KW = .24
                AIR-CHANGES/HR = 1.0 ..

               NORTH-LOBBY-NORTH = EXTERIOR-WALL
                    HEIGHT = 19.5   WIDTH = 69.9
                    CONSTRUCTION = PRE-CAST-CONCRETE
                    LOCATION = BACK ..

                    NORTH-DOOR = WINDOW
                          GLASS-TYPE = GLASS-DOOR
                          X = 43.9  Y=0
                          HEIGHT = 17.6  WIDTH = 26.0 ..

               NORTH-LOBBY-FLOOR = INTERIOR-WALL
                    HEIGHT = 5.88
                    WIDTH = 69.9
                    LOCATION = BOTTOM
                    CONSTRUCTION = CONCRETE-FLOOR
                    NEXT-TO = LOBBY-A ..

               NORTH-LOBBY-ROOF = ROOF
                    CONSTRUCTION = ROOF-CONS
                    HEIGHT = 5.88  WIDTH = 69.9
                    LOCATION = TOP ..

LOBBY-1 = SPACE
               X = 83.88  Y=0   Z=15
               SHAPE = BOX
               HEIGHT = 19.5   WIDTH = 28  DEPTH = 36
               SPACE-CONDITIONS = CONDITIONS
               NUMBER-OF-PEOPLE = 2
               LIGHTING-TYPE = INCAND
               LIGHTING-KW = 2.4
```

```
AIR-CHANGES/HR = 1.0 ..

LOBBY-1-NORTH = INTERIOR-WALL
      HEIGHT = 19.5  WIDTH = 28
      LOCATION = BACK
      CONSTRUCTION = NO-WALL
      NEXT-TO = NORTH-LOBBY ..

LOBBY-1-SOUTH = EXTERIOR-WALL
      CONSTRUCTION = PRE-CAST-CONCRETE
      HEIGHT = 19.5
      WIDTH = 28
      LOCATION = FRONT ..

LOBBY-1-FLOOR = INTERIOR-WALL
      HEIGHT = 36  WIDTH = 28
      LOCATION = BOTTOM
      CONSTRUCTION = CONCRETE-FLOOR
      NEXT-TO = LOBBY-A ..

LOBBY-1-ROOF = ROOF
      CONSTRUCTION = ROOF-CONS
      HEIGHT = 36  WIDTH = 28
      LOCATION = TOP ..

SUBSONIC = SPACE
                        LIKE TRISONIC
                            X=0  WIDTH = 83.88
                            NUMBER-OF-PEOPLE = 6
                            LIGHTING-KW = 7.1
                            EQUIP-SCHEDULE = FIVE-HOURS
                            EQUIPMENT-KW = 150 ..

                            SUBSONIC-FLOOR = INTERIOR-WALL
                                  HEIGHT = 41.88   WIDTH = 69.9
                                  LOCATION = BOTTOM
                                  CONSTRUCTION = CONCRETE-FLOOR
                                  NEXT-TO = SHOP ..

                            SUBSONIC-NORTH = EXTERIOR-WALL
                                  CONSTRUCTION = PRE-CAST-CONCRETE
                                  HEIGHT = 19.5
                                  LOCATION = BACK
                                  WIDTH = 83.88 ..

                            SUBSONIC-SOUTH = EXTERIOR-WALL
                                  LIKE TRISONIC-SOUTH
                                  WIDTH = 83.88 ..

                            SUBSONIC-ROOF = ROOF
                                  LIKE TRISONIC-ROOF
                                  WIDTH = 83.88 ..

                            SUBSONIC-WEST = EXTERIOR-WALL
                                  LIKE TRISONIC-EAST
                                  LOCATION = LEFT ..

                            SUBSONIC-EAST = INTERIOR-WALL
                                  HEIGHT = 19.5  WIDTH = 41.88
                                  LOCATION = RIGHT
                                  CONSTRUCTION = CONCRETE-BLOCK
                                  NEXT-TO = LOBBY-1 ..

                 $*********   SPACES - LOWER LEVEL A    ******$
```

```
SHOP = SPACE
                  SHAPE = BOX
                  HEIGHT = 15  WIDTH = 111.8
                  DEPTH = 41.88
                  SPACE-CONDITIONS = CONDITIONS
                  NUMBER-OF-PEOPLE = 4
                  LIGHTING-KW = 10.4
                  EQUIP-SCHEDULE = FIVE-HOURS
                  EQUIPMENT-KW = 50 ..

                  SHOP-NORTH = UNDERGROUND-WALL
                        HEIGHT = 15  WIDTH = 111.8
                        LOCATION = BACK
                        CONSTRUCTION = POURED-CONCRETE ..

                  SHOP-SOUTH = EXTERIOR-WALL
                        CONSTRUCTION = POURED-CONCRETE
                        HEIGHT = 15   WIDTH = 111.8
                        LOCATION = FRONT ..

                        SHOP-1 = DOOR
                              HEIGHT = 11.25  WIDTH = 14.0
                              CONSTRUCTION = ROLL-UP-DOOR
                              X = 35
                              Y = 0 ..

                        SHOP-2 = DOOR
                              HEIGHT = 11.33  WIDTH = 13.5
                              CONSTRUCTION = STEEL-PANEL-DOOR
                              X = 88.3  Y = 0 ..

                   SHOP-FLOOR = UNDERGROUND-FLOOR
                        HEIGHT = 41.88 WIDTH = 111.8
                        LOCATION = BOTTOM
                        CONSTRUCTION = CONCRETE-FLOOR ..

                   SHOP-EAST = INTERIOR-WALL
                        HEIGHT = 15  WIDTH = 41.88
                        LOCATION = RIGHT
                        CONSTRUCTION = CONCRETE-BLOCK
                        NEXT-TO = LOBBY-A ..

LOBBY-A = SPACE
                  X = 111.8  Y = 5.88  Z = 0
                  SHAPE = BOX
                  HEIGHT = 15  WIDTH = 28  DEPTH = 36
                  SPACE-CONDITIONS = CONDITIONS
                  LIGHTING-TYPE = INCAND
                  LIGHTING-KW = 1.96 ..

                  LOBBY-A-SOUTH = INTERIOR-WALL
                        HEIGHT = 15  WIDTH = 28
                        LOCATION = FRONT
                        CONSTRUCTION = NO-WALL
                        NEXT-TO = SOUTH-LOBBY ..

                  LOBBY-A-NORTH = UNDERGROUND-WALL
                        HEIGHT = 15  WIDTH = 28
                        LOCATION = BACK
                        CONSTRUCTION = POURED-CONCRETE ..

                  LOBBY-A-FLOOR = UNDERGROUND-FLOOR
                        HEIGHT = 36
```

```
                        WIDTH = 29
                        LOCATION = BOTTOM
                        CONSTRUCTION = CONCRETE-FLOOR ..

SOUTH-LOBBY = SPACE
                   X = 111.8
                   Y = 0   Z = 0
                   SHAPE = BOX
                   HEIGHT = 15  WIDTH = 28  DEPTH = 5.88
                   SPACE-CONDITIONS = CONDITIONS
                   LIGHTING-TYPE = INCAND
                   LIGHTING-KW = .4 ..

                   SOUTH-LOBBY-SOUTH = EXTERIOR-WALL
                        CONSTRUCTION = POURED-CONCRETE
                        HEIGHT = 15  WIDTH = 28
                        LOCATION = FRONT ..

                        LOBBY-A-DOOR = WINDOW
                             GLASS-TYPE = GLASS-DOOR
                             X=7  Y=0
                             HEIGHT = 11.25  WIDTH = 13.5 ..

                   SOUTH-LOBBY-FLOOR = UNDERGROUND-FLOOR
                        HEIGHT = 5.88 WIDTH = 28
                        LOCATION = BOTTOM
                        CONSTRUCTION = CONCRETE-FLOOR ..

MECHANICAL = SPACE
                   X = 139.8  Y = 0 Z = 0
                   SHAPE = BOX
                   HEIGHT = 15  WIDTH = 84  DEPTH = 41.88
                   SPACE-CONDITIONS = CONDITIONS
                   NUMBER-OF-PEOPLE = 2
                   LIGHTING-TYPE = INCAND
                   LIGHTING-KW = 4.4
                   EQUIP-SCHEDULE = PEOPLE-LIGHTS
                   EQUIPMENT-KW = 50 ..

                   MECHANICAL-EAST = INTERIOR-WALL
                        HEIGHT = 15
                        WIDTH = 41.89
                        LOCATION = RIGHT
                        CONSTRUCTION = CONCRETE-FLOOR
                        NEXT-TO = TEST-CELL ..

                   MECHANICAL-WEST = INTERIOR-WALL
                        HEIGHT = 15  WIDTH = 41.88
                        LOCATION = LEFT
                        CONSTRUCTION = CONCRETE-BLOCK
                        NEXT-TO = LOBBY-A ..

                   MECHANICAL-SOUTH = EXTERIOR-WALL
                        CONSTRUCTION = POURED-CONCRETE
                        HEIGHT = 15  WIDTH = 84
                        LOCATION = FRONT ..

                        MECH-DOORS = DOOR
                             HEIGHT = 11.25
                             WIDTH = 13.5
                             CONSTRUCTION = STEEL-PANEL DOOR
                             X = 7.25  Y = 0  MULTIPLIER = 3 ..
                   MECHANICAL-FLOOR = UNDERGROUND-FLOOR
                        HEIGHT = 41.88  WIDTH = 84
```

```
                  LOCATION = BOTTOM
                  CONSTRUCTION = CONCRETE-FLOOR ..

            MECHANICAL-NORTH = UNDERGROUND-WALL
                  HEIGHT = 15  WIDTH = 84
                  LOCATION = BACK
                  CONSTRUCTION = POURED-CONCRETE ..

TEST-CELL = SPACE
            X = 223.8  Y = 0  Z = 0
            SHAPE = BOX
            HEIGHT = 15  WIDTH = 56  DEPTH = 58
            SPACE-CONDITIONS = CONDITIONS
            LIGHTING-TYPE = INCAND
            LIGHTING-KW = 8.4 ..

            TEST-CELL-SOUTH = EXTERIOR-WALL
                  CONSTRUCTION = POURED CONCRETE
                  HEIGHT = 15  WIDTH = 56
                  LOCATION = FRONT ..

                  TEST-CELL-DOORS = DOOR
                        HEIGHT = 11.0  WIDTH = 14
                        CONSTRUCTION = ROLL-UP DOOR
                        X = 0  Y = 0  MULTIPLIER = 4 ..
            TEST-CELL-WALL = UNDERGROUND-WALL
                  HEIGHT = 15  WIDTH = 114
                  LOCATION = BACK
                  CONSTRUCTION = POURED-CONCRETE ..

            TEST-CELL-ROOF = UNDERGROUND-WALL
                  HEIGHT = 58  WIDTH = 56
                  LOCATION = TOP
                  CONSTRUCTION = UNDERGROUND-ROOF ..

            TEST-CELL-FLOOR = UNDERGROUND-FLOOR
                  HEIGHT = 58
                  WIDTH = 56
                  LOCATION = BOTTOM
                  CONSTRUCTION = CONCRETE-FLOOR ..
TEST-CELL-CR = SPACE
            X = 279.9  Y = 0   Z = 0
            SHAPE = BOX
            HEIGHT = 15  WIDTH = 54  DEPTH = 58
            SPACE-CONDITIONS = CONDITIONS
            NUMBER-OF-PEOPLE = 13
            LIGHTING-KW = 5.2 ..

            TEST-CELL-CR-SOUTH = EXTERIOR-WALL
                  CONSTRUCTION = POURED CONCRETE
                  HEIGHT = 15  WIDTH = 54
                  LOCATION = FRONT ..

                  TEST-CELL-CR-DOOR = DOOR
                        HEIGHT = 11  WIDTH = 6
                        CONSTRUCTION = STEEL-PANEL-DOOR
                        X = 10.6   Y = 0  MULTIPLIER = 2

            TEST-CELL-CR-ROOF = UNDERGROUND WALL
                  HEIGHT = 58  WIDTH = 54
                  LOCATION = TOP
                  CONSTRUCTION = UNDERGROUND-ROOF ..
```

```
                    TEST-CELL-CR-FLOOR = UNDERGROUND-FLOOR
                          HEIGHT = 58  WIDTH = 54
                          CONSTRUCTION = CONCRETE-FLOOR ..

                    TEST-CELL-CR-INT = INTERIOR-WALL
                          HEIGHT = 15
                          WIDTH = 170
                          LOCATION = BACK
                          CONSTRUCTION = TCCR-WALL
                          NEXT-TO = TEST-CELL ..
BUILDING-RESOURCE
                    HW-SCHEDULE = PEOPLE-LIGHTS
                    HOT-WATER = 4700 ..


LOADS-REPORT
               SUMMARY = (ALL-SUMMARY)  ..

END ..

COMPUTE LOADS ..
INPUT SYSTEMS ..
```

S D L   P R O C E S S O R   I N P U T   D A T A

82/10/17.   15:32:31.   SDL RUN 1

```
HEAT=SCHEDULE
                   THRU MAY 15 (ALL)
                   (1,7)(62.5)(8,17)(70.5)(18,24)(62.5)
                   THRU SEP 30 (ALL)
                   (1,7)(62.5)(8,17)(70.5)(18,24)(62.5)
                   THRU DEC 31 (ALL)
                   (1,7)(62.5)(8,17)(70.5)(18,24)(62.5) ..
COOL=SCHEDULE
                   THRU MAY 15 (ALL)
                   (1,7)(67.5)(8,17)(75.5)(18,24)(67.5)
                   THRU SEP 30 (ALL)
                   (1,7)(57.5)(8,17)(75.5)(18,24)(67.5)
                   THRU DEC 31 (ALL)
                   (1,7)(67.5)(8,17)(75.5)(18,24)(67.5) ..

HEAT2=SCHEDULE
                   THRU MAY 15 (ALL)
                   (1,7)(60.0)(8,17)(68.0)(18,24)(50.0)
                   THRU SEP 30 (ALL)
                   (1,7)(60.0)(8,17)(58.0)(18,24)(60.0)
                   THRU DEC 31 (ALL)
                   (1,7)(60.0)(8,17)(68.0)(18,24)(60.0) ..
COOL2=SCHEDULE
                   THRU MAY 15 (ALL)
                   (1,7)(90.0)(8,17)(78.0)(18,24)(90.0)
                   THRU SEP 30 (ALL)
                   (1,7)(90.0)(8,17)(78.0)(18,24)(90.0)
                   THRU DEC 31 (ALL)
                   (1,7)(90.0)(8,17)(78.0)(18,24)(90.0) ..


HEAT1 = SCHEDULE THRU DEC 31 (ALL)
              (1,7)(62.5)(8,17)(70.5)(18,24)(62.5)  ..

COOL1 = SCHEDULE THRU DEC 31 (ALL)
              (1,7)(67.5)(8,17)(75.5)(18,24)(67.5)  ..

MIN-AIR = SCHEDULE
               THRU DEC 31(ALL)(1,7)(0)
                         (8,17)(.041)
                         (18,24)(0)  ..
MIN-AIR1 = SCHEDULE
               THRU DEC 31(ALL)(1,7)(0)
                         (8,17)(.12)
                         (18,24)(0)  ..

MECH-HTG=SCHEDULE
                   THRU MAY 15 (ALL)(1,24)(1)
                   THRU SEP 30 (ALL)(1,24)(1)
                   THRU DEC 31 (ALL)(1,24)(1) ..
MECH-CLG=SCHEDULE
                   THRU DEC 31 (ALL)(1,7)(0)(8,17)(1)(18,24)(0) ..

MECH-COOL = SCHEDULE THRU DEC 31 (ALL)
              (1,24)(.5)  ..
```

```
S1-FANS = SCHEDULE
                THRU DEC 31 (WD)(1,7)(0)
                                (8,17)(1)
                                (18,24)(0)
                              (WEH)(1,24)(0) ..

TEST-CELL-HEAT = SCHEDULE
                THRU DEC 31 (ALL)(1,24)(60) ..

LOBBY = SCHEDULE
                     THRU DEC 31 (ALL)(1,7)(68)(8,17)(68)(18,24)(68) ..

REPORT = SCHEDULE
                 THRU JAN 13 (ALL)(1,24)(1)
                 THRU JUN 17 (ALL)(1,24)(0)
                 THRU JUN 27  (ALL)(1,24)(1)
                 THRU DEC 31 (ALL)(1,24)(0) ..

Z-CONTROL = ZONE-CONTROL
                DESIGN-HEAT-T = 70
                HEAT-TEMP-SCH = HEAT
                DESIGN-COOL-T = 71
                COOL-TEMP-SCH = COOL
                THROTTLING-RANGE = 5.0  ..

Z-CTRL = ZONE-CONTROL
                DESIGN-HEAT-T = 70
                HEAT-TEMP-SCH = HEAT1
                DESIGN-COOL-T = 75
                COOL-TEMP-SCH = COOL1
                THROTTLING-RANGE = 5.0  ..
SUBSONIC = ZONE
              $ ASSIGNED-CFM = 5677
                DESIGN-HEAT-T=70
                HEAT-TEMP-SCH=HEAT2
                DESIGN-COOL-T=71
                COOL-TEMP-SCH=COOL2
                THERMOSTAT-TYPE=TWO-POSITION ..

LOBBY-1 = ZONE
              $ ASSIGNED-CFM = 385
                ZONE-CONTROL = Z-CONTROL ..

SHOP = ZONE
              $ ASSIGNED-CFM = 1385
                ZONE-CONTROL = Z-CONTROL ..

COMBUSTION = ZONE
              $ ASSIGNED-CFM = 2154
                ZONE-CONTROL = Z-CONTROL ..

TRISONIC = ZONE
              $ ASSIGNED-CFM = 4231
                ZONE-CONTROL = Z-CONTROL ..
MECHANICAL = ZONE
                DESIGN-HEAT-T = 60
                HEAT-TEMP-SCH = TEST-CELL-HEAT
                DESIGN-COOL-T = 75
                COOL-TEMP-SCH = MECH-COOL
                ASSIGNED-CFM = 4385  ..

TEST-CELL = ZONE
                DESIGN-HEAT-T = 60
```

```
                 HEAT-TEMP-SCH = TEST-CELL-HEAT
                 ASSIGNED-CFM = 2277
                 DESIGN-COOL-T = 80
                 HEATING-CAPACITY = -136000

TEST-CELL-CR = ZONE
                 ZONE-CONTROL = Z-CTRL
                 ASSIGNED-CFM = 2569
                 HEATING-CAPACITY= -154000
                 COOLING-CAPACITY = 92400 ..

LOBBY-A = ZONE
                 DESIGN-HEAT-T = 72
                 HEAT-TEMP-SCH = LOBBY
                 DESIGN-COOL-T = 80
                 BASEBOARD-CTRL = THERMOSTATIC
                 BASEBOARD-RATING = -8000
                 ASSIGNED-CFM = 400 ..

SOUTH-LOBBY = ZONE
                 DESIGN-HEAT-T = 72
                 HEAT-TEMP-SCH = LOBBY
                 DESIGN-COOL-T = 80
                 ASSIGNED-CFM = 446 ..
NORTH-LOBBY = ZONE
                 DESIGN-HEAT-T = 72
                 HEAT-TEMP-SCH = LOBBY
                 DESIGN-COOL-T = 80
                 ASSIGNED-CFM = 669 ..

S1SUB=SYSTEM
                 ZONE-NAMES=(SUBSONIC)
                 SYSTEM-TYPE=SZRH
                 MAX-SUPPLY-T=120
                 MIN-SUPPLY-T=54
                 ECONO-LIMIT-T=78
                 HEATING-SCHEDULE=MECH-HTG
               $ COOLING-SCHEDULE=MECH-CLG
                 SUPPLY-CFM=26923
                 COOL-CTRL-RANGE=2.0
                 MIN-AIR-SCH=MIN-AIR
                 NIGHT-CYCLE-CTRL=CYCLE-ON-ANY
                 FAN-SCHEDULE=S1-FANS ..

S1 = SYSTEM
                 SYSTEM-TYPE = MZS
                 ZONE-NAMES = (LOBBY-1,SHOP,COMBUSTION,TRISONIC)
                 MAX-SUPPLY-T = 100
                 MIN-SUPPLY-T = 51
                 HEAT-CONTROL = CONSTANT
                 COOL-CONTROL = CONSTANT
                 COOL-SET-T = 64
                 ECONO-LIMIT-T = 78
                 SUPPLY-CFM = 13831
                 COOL-CTRL-RANGE = 2.0
                 MIN-AIR-SCH = MIN-AIR
                 SUPPLY-KW = .00026
                 RETURN-KW = .00023
                 RETURN-DELTA-T = .70
                 SUPPLY-DELTA-T = 1.2
                 HEATING-SCHEDULE=MECH-HTG
               $ COOLING-SCHEDULE=MECH-CLG
                 COOLING-CAPACITY = 5[illegible]
                 HEATING-CAPACITY = -260[illegible]
```

```
                   NIGHT-CYCLE-CTRL = CYCLE-ON-ANY
                   FAN-SCHEDULE = S1-FANS

UH-4 = SYSTEM
                   SYSTEM-TYPE = UHT
                   ZONE-NAMES = (MECHANICAL)
                   MAX-SUPPLY-T = 68.5
                   MIN-OUTSIDE-AIR = 0.0
                   HEATING-SCHEDULE=MECH-HTG
                   HEATING-CAPACITY = -4000

UH-5-8 = SYSTEM
                   SYSTEM-TYPE = UHT
                   ZONE-NAMES =(TEST CELL)
                   MAX-SUPPLY-T = 115
                   HEATING-SCHEDULE=MECH-HTG
                   HEATING-CAPACITY = -106[illegible]

S-2-3 = SYSTEM
                   SYSTEM-TYPE = TPFC
                   ZONE-NAMES =(TEST CELL CR)
                   MAX-SUPPLY-T = 124
                   MIN-SUPPLY-T = 54
                   SUPPLY-KW = (0.6)
                   MIN-AIR-SCH = MIN-AIR1
                   HEATING-SCHEDULE=MECH-HTG
                   COOLING-SCHEDULE = MECH-CLG
                   FAN-SCHEDULE = S1-FANS
                   NIGHT-CYCLE-CTRL = CYCLE-ON-ANY
                   SUPPLY-DELTA-T = [illegible]
                   COOLING-CAPACITY = [illegible]
                   HEATING-CAPACITY = -1[illegible]

UH-2 = SYSTEM
                   SYSTEM-TYPE = UHT
                   ZONE-NAMES = ([illegible]-A,SOUTH-LIBRARY)
                   MAX-SUPPLY-T = [illegible]
                   HEATING-SCHEDULE=MECH-HTG
                   HEATING-CAPACITY = -3[illegible]

UH-1 = SYSTEM
                   SYSTEM-TYPE = UHT
                   ZONE-NAMES =(NORTH-LIBRARY)
                   MAX-SUPPLY-T = [illegible]
                   HEATING-SCHEDULE=MECH-HTG
                   HEATING-CAPACITY = -5350[illegible]

SYSTEMS-REPORT
                   SUMMARY = (ALL-SUMMARY)

RPT = HOURLY-REPORT
                    REPORT-SCHEDULE = [illegible]
                    REPORT-BLOCK = (*SUBSONIC,*SHOP,*S1)

*SUBSONIC = REPORT-BLOCK
                    VARIABLE-TYPE = SUBSONIC
                    VARIABLE-LIST = (6,12,13)

*SHOP = REPORT-BLOCK
                   VARIABLE-TYPE = SHOP
                    VARIABLE-LIST = (6,12,13)

*S1 = REPORT-BLOCK
                    VARIABLE-TYPE = S1
```

```
                    VARIABLE-LIST = (1,2,4,53,19,20)

END ..

COMPUTE SYSTEMS ..

INPUT PLANT ..
```

P D L   P R O C E S S O R   I N P U T   D A T A

22/10/17.   15.32.31.   PDL RUN 1

```

ABS-COOL = PLANT-EQUIPMENT
                  TYPE = ABSOR1-CHLR
                  SIZE = -999 ..

HOT-WATER = PLANT-EQUIPMENT
                  TYPE = ELEC-DHW-HEATER
                  SIZE = -999 ..

*HEAT = LOAD-ASSIGNMENT
                  TYPE = HEATING
                  LOAD-RANGE = 999
                  PLANT-EQUIPMENT = UTILITY
                  NUMBER = 999 ..

LOAD-MANAGEMENT
                  PRED-LOAD-RANGE = 999
                  LOAD-ASSIGNMENT = (*HEAT,DEFAULT,DEFAULT)

ENERGY-COST
                  RESOURCE = STEAM
                  UNIT = 1000000 ..

PLANT-REPORT
                 SUMMARY = (PS-A,PS-B,PS-C,PS-D,PS-G,PS-H,PS-I,PS-F)

END ..

COMPUTE PLANT ..

STOP ..
```

APPENDIX B
ECONOMIC ANALYSIS

I. ECONOMIC ANALYSIS OF ENERGY CONSERVATION OPPORTUNITIES

All proposed energy conservation opportunities (ECOs) were evaluated using the Department of Defense Energy Conservation Investment Program (ECIP) Guidance dated July 22, 1981. These guidelines require a two-part economic analysis consisting of a documented cost estimate and a life-cycle cost analysis for each alternative or combination of alternatives that constitute a project.

A. Economic Criteria

The economic criteria applied to each ECO are prescribed by the guidance as follows.

1. All projects must be cost effective, that is, Benefit/Cost Ratio (B/C) $\geq$ 1.
2. All projects must produce an energy-to-cost ratio (E/C) equal to or greater than 15.
3. All discrete portions of each project, that is ECOs, must meet both the E/C ratio minimum requirements and be life-cycle cost effective.
4. No more than 25% of the total annual savings shall be attributed to nonenergy sources.

B. Economic Parameters

We were instructed by the Air Force Academy to apply the same economic parameters as used for the FY 1983 ECIP submittals.

1. The short-term differential escalation rates applied to the end of the fiscal year in which construction was programmed were:

Design	6.0%
Construction	6.0%
Supervision, inspection, and overhead	6.0%
Fuel oil	14.0%
Electricity	13.0%

2. The long-term differential escalation rates for computing the present worth of recurring annual costs/benefits were:

Maintenance and repair; O and M	0.0%
Fuel oil	8.0%
Electricity	7.0%

3. The discount factor to be applied to the present worth of recurring annual costs/benefits was 10 .

C. Fuel Costs

The Air Force provided us with the following FY 1981 site fuel costs that we converted to FY 1984 fuel costs at the source.

$$\text{Fuel oil: } \frac{(\$1.29/\text{gal.}) \times 10^6 \text{ Btu}}{(138{,}700 \text{ Btu/gal.})} = \$9.30/10^6 \text{Btu.}$$

$$\text{Electricity: } \frac{(\$0.02468/\text{kWh})(10^6 \text{ Btu})}{(3413 \text{ Btu/kWh})} = \$7.23/10^6 \text{ Btu.}$$

When escalated to FY 1984, the fuel prices become

$$\text{Fuel oil: } \frac{\$9.30}{10^6} \times (1.14)^3 = \$13.78/10^6 \text{ Btu , and}$$

$$\text{Electricity: } \frac{\$7.23}{10^6} \times (1.13)^3 = \$10.44/10^6 \text{ Btu ;}$$

when adjusted by the energy conversion factors* for fuel use at the souce,

Fuel oil: $\$13.78/10^6$ Btu, and
Electricity: $\$10.44/10^6$ Btu x 3,413/11,600* = $\$3.07/10^6$ Btu.

The latter rates are cost savings in FY 1984 dollars for every 10^6 Btu's saved at the source.

Although natural gas is consumed by the boilers supporting the high-temperature water distribution system, the Air Force Academy instructed us to evaluate energy cost savings for the natural gas heating system on the basis of equivalent fuel oil prices and fuel oil escalation.

D. Methodology

The first step in the economic analysis of an ECIP project is to develop a Current Working Estimate (CWE). We were instructed by the Air Force Academy to develop this estimate by calculating the maximum amount of capital that could be invested in a project to displace a unit of the fuel and remain cost effective. The following outlines the calculation procedure for fuel oil and electricity, respectively.

1. <u>Nonrecurring initial capital costs.</u>

Construction bids (by definition P dollars)	= 1.00 P
Contingency at 15%	= 0.15 P
Unescalated CWE	= 1.15 P
CWE escalated to end of FY 1984 = $1.15\,(1.06)^3$ P	= 1.37 P
Unescalated design at 15%	= 0.15 P
Design escalated to end of FY 1983 = $0.15\,(1.06)^2$	= 0.18 P
Salvage Value	= 0.00 P

2. <u>Recurring costs.</u>

Additional O and M at 3%	= 0.03 P

3. <u>Maximum capital investment.</u> For fuel oil, one can afford to invest \$95.24 for each 10^6 Btu saved at the building boundary for projects with an economic life of either 15 or 25 years. For electricity, one can afford to invest \$103.85 and \$148.81 for each 10^6 Btu saved at the building boundary for projects with an economic life of 15 and 25 years, respectively. For fuel oil, the economic criterion that established the maximum investment is the E/C ratio = 15, and for electricity, the B/C ratio = 1.0. An example illustrates the development of the maximum capital investment.

Let us assume that a project has a CWE of \$95.24 and displaces 1.0×10^6 Btu of fuel oil at the building boundary. Thus,

$$\text{Design cost} = 0.18\text{ P} = (.18)\left(\frac{\$95.24}{1.37}\right) = \$12.56.$$

$$\text{Salvage cost} = 0.0\text{ P} = \$0.00.$$

$$\text{O and M cost} = 0.03\text{ P} = (.03)\left(\frac{\$95.24}{1.37}\right) = \$2.09.$$

Inserting these costs into Fig. B-1 (the Form A-1 entitled "ECIP Economic Analysis Summary"), one can see that E/C = 15 and B/C > 1.0. If the CWE were larger than $95.24, then E/C < 15. Thus, the maximum capital investment for fuel oil displacement of 10^6 Btu is established.

A similar calculation was performed for ECIP projects with fuel oil savings for 25 years and electrical energy savings for 15 and 25 years. Figures B-2 through B-4, showing these calculations, are attached.

The second step in the economic analysis of an ECIP project is the life-cycle cost evaluation. ECIP guidelines require that the E/C ratio be used in ranking projects and that projects must have a B/C ratio of 1.0 or greater. The B/C ratio is an index of the life-cycle cost effectiveness of a project as an investment opportunity. It shows the number of dollars that will be saved for each dollar that is invested in the project. The higher the B/C ratio, the more attractive the project. The E/C ratio shows the amount of energy savings in Btu x 10^6 (MBtu) per $1000 of project cost. The E/C ratio ensures that projects will be prioritized by the criterion of greatest energy savings per investment dollar. Another project comparison index is the payback period, which is determined by dividing the annual cost savings into the CWE. The payback period is not involved in project ranking but is included because it is a familiar evaluation index. The life-cycle cost is determined by adding the discounted benefits and costs of a project over its life to the project's implementation cost. The procedure for evaluating life-cycle cost is shown in Figs. B-1 through B-4 (the Form A-1, "ECIP Economic Analysis Summary"). The life-cycle costing results for the proposed ECIP projects are summarized in the next section.

II. SUMMARY OF ECONOMIC RESULTS

A summary of the economic results is provided in Tables B-I through B-VI.

III. DOCUMENTATION OF ECONOMIC ANALYSIS

The documentation for the economic analysis of the ECIP projects proposed for Vandenberg Hall, the Field House, and the Aeronautics Laboratory is attached as pages 93-123.

Fig. 6-1

FORM A-1

ECIP ECONOMIC ANALYSIS SUMMARY

Location: [illegible] FY [illegible]

Project: [illegible]

[illegible]

Economic Life: 15 Yrs. Date Prepared [illegible] Prepared by [illegible]

COSTS

1. Non-recurring Initial Capital Costs:
   - a. CWE $ [illegible]
   - b. Design $ [illegible]
   - c. Salvage $
   - d. Total $ [illegible]

BENEFITS

2. Recurring Benefit/Cost Differential Other Than Energy:
   - a. Annual Labor Decrease (+)/Increase (-) $ [illegible] /Yr.
   - b. Annual Material Decrease (+)/Increase (-) $ [illegible] /Yr.
   - c. Other Annual Decrease (+)/Increase (-) $ [illegible] /Yr.
   - d. Total Costs $ [illegible] /Yr.
   - e. 10% Discount Factor $ [illegible]
   - f. Discounted Recurring Cost (d x e) $ [illegible]
3. Recurring Energy Benefit/Costs:
   - a. Type of Fuel: [illegible]
     - (1) Annual Energy Decrease (+)/Increase (-) [illegible] MBTU
     - (2) Cost per MBTU $ [illegible] /MBTU
     - (3) Annual Dollar Decrease/Increase ((1)x(2)) $ [illegible] /Yr.
     - (4) Differential Escalation Rate ([illegible] %) Factor [illegible]
     - (5) Discounted Dollar Decrease/Increase (3)x(4) $ [illegible]
   - b. Type of Fuel:
     - (1) Annual Energy Decrease (+)/Increase (-) MBTU
     - (2) Cost per MBTU $ /MBTU
     - (3) Annual Dollar Decrease/Increase ((1)x(2)) $ /Yr.
     - (4) Differential Escalation Rate (__ %) Factor
     - (5) Discounted Dollar Decrease/Increase ((3)x(4)) $
   - c. Type of Fuel:
     - (1) Annual Energy Decrease (+)/Increase (-) MBTU
     - (2) Cost per MBTU $ /MBTU
     - (3) Annual Dollar Decrease/Increase ((1)x(2)) $ /Yr.
     - (4) Differential Escalation Rate (__ %) Factor
     - (5) Discounted Dollar Decrease/Increase ((3)x(4)) $
   - d. Type of Fuel:
     - (1) Annual Energy Decrease (+)/Increase (-) MBTU
     - (2) Cost per MBTU $ /MBTU
     - (3) Annual Dollar Decrease/Increase ((1)x(2)) $ /Yr.
     - (4) Differential Escalation Rate (__ %) Factor
     - (5) Discounted Dollar Decrease/Increase ((3)x(4)) $
   - e. Discounted Energy Benefits (3a(5)+3b(5)+3c(5)+3d(5)) $ [illegible]
4. Total Benefits (Sum 2f+3e) $ [illegible]
5. Discounted Benefit/Cost Ratio (Line 4÷Line 1d) [illegible]
6. Total Annual Energy Savings (3a(1)+3b(1)+3c(1)+3d(1)) 1.42 MBTU
7. E/C Ratio (Line 6 ÷ Line 1a/1000) 15.5
8. Annual $ Savings (2d+3a(3)+3b(3)+3c(3)+3d(3)) $ [illegible]
9. Pay-back Period ((Line 1a - Salvage)÷Line 8) 8.41 yrs
10. Life Cycle Cost (Line 1d-2f-3e) - $ [illegible]

Fig. B-2

FORM A-1
ECIP ECONOMIC ANALYSIS SUMMARY

Location: Colorado Springs FY [illegible]
Project: Air Force Academy
[illegible]
Economic Life: 25 Yrs. Date Prepared 9/[illegible] Prepared by [illegible]

COSTS

1. Non-recurring Initial Capital Costs:
   - a. CWE $ [illegible]
   - b. Design $ [illegible]
   - c. Salvage $ [illegible]
   - d. Total $ [illegible]

BENEFITS

2. Recurring Benefit/Cost Differential Other Than Energy:
   - a. Annual Labor Decrease (+)/Increase (-) $ -[illegible] /Yr.
   - b. Annual Material Decrease (+)/Increase (-) $ [illegible] /Yr.
   - c. Other Annual Decrease (+)/Increase (-) $ [illegible] /Yr.
   - d. Total Costs $ -2.[illegible] /Yr.
   - e. 10% Discount Factor $ [illegible]
   - f. Discounted Recurring Cost (d x e) $ -[illegible]
3. Recurring Energy Benefit/Costs:
   - a. Type of Fuel: Fuel Oil
     - (1) Annual Energy Decrease (+)/Increase(-) 1.43 MBTU
     - (2) Cost per MBTU $ [illegible] /MBTU
     - (3) Annual Dollar Decrease/Increase ((1)x(2)) $ [illegible].69 /Yr.
     - (4) Differential Escalation Rate (_ %)Factor [illegible]
     - (5) Discounted Dollar Decrease/Increase(3)x(4) $ [illegible]4.76
   - b. Type of Fuel: ____
     - (1) Annual Energy Decrease (+)/Increase (-) ____ MBTU
     - (2) Cost per MBTU $ ____ /MBTU
     - (3) Annual Dollar Decrease/Increase ((1)X(2)) $ ____ /Yr.
     - (4) Differential Escalation Rate (___%) Factor ____
     - (5) Discounted Dollar Decrease/Increase ((3)x(4)) $ ____
   - c. Type of Fuel: ____
     - (1) Annual Energy Decrease (+)/Increase (-) ____ MBTU
     - (2) Cost per MBTU $ ____ /MBTU
     - (3) Annual Dollar Decrease/Increase ((1)x(2)) $ ____ /Yr.
     - (4) Differential Escalation Rate (__%) Factor ____
     - (5) Discounted Dollar Decrease/Increase ((3)x(4)) $ ____
   - d. Type of Fuel: ____
     - (1) Annual Energy Decrease (+)/Increase (-) ____ MBTU
     - (2) Cost per MBTU $ ____ /MBTU
     - (3) Annual Dollar Decrease/Increase ((1)x(2)) $ ____ /Yr.
     - (4) Differential Escalation Rate (__%)Factor ____
     - (5) Discounted Dollar Decrease/Increase ((3)x(4)) $ ____
   - e. Discounted Energy Benefits (3a(5)+3b(5)+3c(5)+3d(5)) $ [illegible]4.75
4. Total Benefits (Sum 2f+3e) $ [illegible]74.87
5. Discounted Benefit/Cost Ratio (Line 4÷Line 1d) 3.48
6. Total Annual Energy Savings (3a(1)+3b(1)+3c(1)+3d(1)) 1.4[illegible] MBTU
7. E/C Ratio (Line 6 ÷ Line 1a/1000) 15.0
8. Annual $ Savings (2d+3a(3)+3b(3)+3c(3)+3d(3)) $ 17.[illegible]c/yr
9. Pay-back Period ((Line 1a - Salvage)÷Line 8) 5.44 yrs
10. Life cycle Cost (Line 1d - 2f - 3e) -$267.11

Fig. B-3

FORM A-1
ECIP ECONOMIC ANALYSIS SUMMARY

Location: Colorado Springs FY 84
Project: Air Force Academy
[illegible]
Economic Life: 15 Yrs. Date Prepared ______ Prepared by JLP

COSTS
1. Non-recurring Initial Capital Costs:
   a. CWE $ 103.85
   b. Design $ 13.55
   c. Salvage $ 0
   d. Total $ 117.40

BENEFITS
2. Recurring Benefit/Cost Differential Other Than Energy:
   a. Annual Labor Decrease (+)/Increase (-) $ (2.27) /Yr.
   b. Annual Material Decrease (+)/Increase (-) $ 0 /Yr.
   c. Other Annual Decrease (+)/Increase (-) $ 0 /Yr.
   d. Total Costs $ (2.27) /Yr.
   e. 10% Discount Factor $ 7.606
   f. Discounted Recurring Cost (d x e) $ (16.5)
3. Recurring Energy Benefit/Costs:
   a. Type of Fuel: electricity
      (1) Annual Energy Decrease (+)/Increase(-) 3.40 MBTU
      (2) Cost per MBTU $ [illegible] /MBTU
      (3) Annual Dollar Decrease/Increase ((1)x(2)) $ 11.64 /Yr.
      (4) Differential Escalation Rate (7 %)Factor 12.[illegible]
      (5) Discounted Dollar Decrease/Increase(3)x(4) $ [illegible]
   b. Type of Fuel: ______
      (1) Annual Energy Decrease (+)/Increase (-) ______ MBTU
      (2) Cost per MBTU $ ______ /MBTU
      (3) Annual Dollar Decrease/Increase ((1)X(2)) $ ______ /Yr.
      (4) Differential Escalation Rate (___ %) Factor ______
      (5) Discounted Dollar Decrease/Increase ((3)x(4)) $ ______
   c. Type of Fuel: ______
      (1) Annual Energy Decrease (+)/Increase (-) ______ MBTU
      (2) Cost per MBTU $ ______ /MBTU
      (3) Annual Dollar Decrease/Increase ((1)x(2)) $ ______ /Yr.
      (4) Differential Escalation Rate (__ %) Factor ______
      (5) Discounted Dollar Decrease/Increase ((3)x(4)) $ ______
   d. Type of Fuel: ______
      (1) Annual Energy Decrease (+)/Increase (-) ______ MBTU
      (2) Cost per MBTU $ ______ /MBTU
      (3) Annual Dollar Decrease/Increase ((1)x(2)) $ ______ /Yr.
      (4) Differential Escalation Rate (__ %)Factor ______
      (5) Discounted Dollar Decrease/Increase ((3)x(4)) $ ______
   e. Discounted Energy Benefits (3a(5)+3b(5)+3c(5)+3d(5)) $ 125.55
4. Total Benefits (Sum 2f+3e) $ 117.40
5. Discounted Benefit/Cost Ratio (Line 4÷Line 1d) 1.0
6. Total Annual Energy Savings (3a(1)+3b(1)+3c(1)+3d(1)) 3.4 MBtu
7. E/C Ratio (Line 6 ÷ Line 1a/1000) 32.74
8. Annual $ Savings (2d+3a(3)+3b(3)+3c(3)+3d(3)) $ 9.37/yr
9. Pay-back Period ((Line 1a - Salvage)÷Line 8) 11.84 yr
10 Life Cycle cost (Line 1d - 2f - 3e) 0 yr

Fig. 6-4

FORM A-1
ECIP ECONOMIC ANALYSIS SUMMARY

Location: Colorado Springs [illegible] FY 84
Project: Air Force Academy [illegible]
[illegible]
Economic Life: 25 Yrs. Date Prepared [illegible] Prepared by [illegible]

COSTS
1. Non-recurring Initial Capital Costs:
   a. CWE $ 148.61
   b. Design $ 19.41
   c. Salvage $ 0
   d. Total $ [illegible]

BENEFITS
2. Recurring Benefit/Cost Differential Other Than Energy:
   a. Annual Labor Decrease (+)/Increase (-) $ (3.26) /Yr.
   b. Annual Material Decrease (+)/Increase (-) $ 0.00 /Yr.
   c. Other Annual Decrease (+)/Increase (-) $ 0.00 /Yr.
   d. Total Costs $ (3.26) /Yr.
   e. 10% Discount Factor $ [illegible]
   f. Discounted Recurring Cost (d x e) $ ([illegible]4)
3. Recurring Energy Benefit/Costs:
   a. Type of Fuel: Electricity
      (1) Annual Energy Decrease (+)/Increase(-) 2.40 MBTU
      (2) Cost per MBTU $ [illegible] /MBTU
      (3) Annual Dollar Decrease/Increase ((1)x(2)) $ [illegible] /Yr.
      (4) Differential Escalation Rate (__%) Factor [illegible]
      (5) Discounted Dollar Decrease/Increase(3)x(4) $ [illegible]
   b. Type of Fuel: ______
      (1) Annual Energy Decrease (+)/Increase (-) ______ MBTU
      (2) Cost per MBTU $______ /MBTU
      (3) Annual Dollar Decrease/Increase ((1)x(2)) $______ /Yr.
      (4) Differential Escalation Rate (___%) Factor ______
      (5) Discounted Dollar Decrease/Increase ((3)x(4)) $______
   c. Type of Fuel: ______
      (1) Annual Energy Decrease (+)/Increase (-) ______ MBTU
      (2) Cost per MBTU $______ /MBTU
      (3) Annual Dollar Decrease/Increase ((1)x(2)) $______ /Yr.
      (4) Differential Escalation Rate (__%) Factor ______
      (5) Discounted Dollar Decrease/Increase ((3)x(4)) $______
   d. Type of Fuel: ______
      (1) Annual Energy Decrease (+)/Increase (-) ______ MBTU
      (2) Cost per MBTU $______ /MBTU
      (3) Annual Dollar Decrease/Increase ((1)x(2)) $______ /Yr.
      (4) Differential Escalation Rate (__%) Factor ______
      (5) Discounted Dollar Decrease/Increase ((3)x(4)) $______
   e. Discounted Energy Benefits (3a(5)+3b(5)+3c(5)+3d(5)) $ 109.26
4. Total Benefits (Sum 2f+3e) $ [illegible].2
5. Discounted Benefit/Cost Ratio (Line 4÷Line 1d) [illegible]
6. Total Annual Energy Savings (3a(1)+3b(1)+3c(1)+3d(1)) [illegible] MBtu
7. E/C Ratio (Line 6 ÷ Line 1a/1000) [illegible].55
8. Annual $ Savings (2d+3a(3)+3b(3)+3c(3)+3d(3)) $ [illegible] /yr
9. Pay-back Period ((Line 1a - Salvage)÷Line 8) [illegible] yrs
10. Life Cycle Cost (Line 1d - 2f - 3e) $ 0

TABLE B-I

ECONOMIC SUMMARY OF ENERGY CONSERVATION OPTIONS FOR VANDENBERG HALL

	Option	Estimated Energy Use ($Btu/ft^2/yr$)	% Energy Reduction	Estimated Annual Savings		10^6 Btu Saved per $1000 Invested	Maximum Investment ($)	Discounted Benefit/ Cost Ratio	Life-Cycle Cost ($1,000)
				$1,000	10^6 Btu				
1.	Baseline, as-built	120,834	--	--	--	-	--	--	--
2.	Reinstate economizer	120,369	1	1	354	36.5	11,023	1.000	0
3.	Zone thermostats for baseboard heaters	116,661	4	34	3,172	15.0	236,612	1.959	-227
4.	Tunnel preheat of ventilation air	116,944	3	36	2,956	15.0	222,717	3.410	-537
5.	Reinstate radiant heating	118,961	2	1	1,423	215.7	7,463	1.000	0
6.	Run-around heat recovery loop	94,320	22	242	20,152	15.0	1,517,967	3.396	-3,638
7.	Minimize ventilation rates	103,350	15	160	13,287	15.0	1,001,360	3.413	-2,417
8.	Improve fan/motor efficiencies	114,637	5	10	4,710	24.2	220,150	1.000	0
9.	Night insulation on windows	119,902	1	9	708	15.0	53,342	3.410	-129
10.	Improve wall and roof insulation	120,532	1	3	229	15.0	17,068	4.114	-53
11.	Combine options 6 and 7	90,887	25	274	22,764	15.0	1,715,586	3.398	-4,114
12.	Combine options 6, 7, and 8	84,681	30	284	27,475	16.0	1,935,966	3.125	-4,114
13.	Combine options 6, 7, 8, and 2	84,217	30	284	27,825	16.1	1,947,720	3.114	-4,117
14.	Combine options 6, 7, 8, 2, and 3	81,730	32	301	29,720	15.4	2,184,332	2.951	-4,263

TABLE B-II

ECONOMIC SUMMARY OF SOLAR OPTIONS FOR VANDENBERG HALL

Option	Estimated Energy Use (Btu/ft^2/yr)	% Energy Reduction	Estimated Annual Savings $1,000	Estimated Annual Savings 10^6 Btu	10^6 Btu Saved per $1000 Invested	Maximum Investment ($)	Discounted Benefit/ Cost Ratio	Life-Cycle Cost ($1,000)
1. Baseline, as-built	120,834	--	--	--	--	--	--	-
2. Solar DHW system	114,042	6	67	5,162	15.0	390,192	3.636	-1,[illegible]

TABLE B-III

ECONOMIC SUMMARY OF ENERGY CONSERVATION OPTIONS FOR FIELD HOUSE

Option	Estimated Energy Use (Btu/ft^2/yr)	% Energy Reduction	Estimated Annual Savings $1,000	Estimated Annual Savings 10^6 Btu	10^6 Btu Saved per $1000 Invested	Maximum Investment ($)	Discounted Benefit/ Cost Ratio	Life-Cycle Cost ($1,000)
1. Baseline	188,281	--	--	--	--	--	--	--
2. Utility tunnel heat recovery	145,432	23	130	10,543	15.0	795,214	3.479	-1,971,176
3. Reduce thermostat setting	168,976	10	48	4,750	15.0	358,273	1.854	[illegible]
4. Add roof insulation	181,221	4	19	1,737	15.0	131,015	3.039	[illegible]
5. Combine options 2 and 3	134,011	29	158	13,353	15.0	1,007,161	3.354	-2,[illegible]
6. Combine options 2, 3, and 4	127,850	32	174	14,869	15.0	1,121,506	3.317	-2,[illegible]

TABLE B-IV

ECONOMIC SUMMARY OF SOLAR OPTIONS FOR FIELD HOUSE

Option	Estimated Energy Use (Btu/ft^2/yr)	% Energy Reduction	Estimated Annual Savings $1,000	Estimated Annual Savings 10^6 Btu	10^6 Btu Saved per $1000 Invested	Maximum Investment ($)	Discounted Benefit/ Cost Ratio	Life-Cycle Cost ($1,000)
1. Baseline	188,281	--	--	--	--	--	--	
2. Solar DHW system	187,150	1	7	[illegible]	15.0	20,441	6.720	[illegible]

TABLE B-V

ECONOMIC SUMMARY OF ENERGY CONSERVATION OPTIONS FOR AERONAUTICS LABORATORY

Option	Estimated Energy Use ($Btu/ft^2/yr$)	% Energy Reduction	Estimated Annual Savings $1,000	Estimated Annual Savings 10^6 Btu	10^6 Btu Saved per $1000 Invested	Maximum Investment ($)	Discounted Benefit/ Cost Ratio	Life Cycle Cost ($1,000)
1. Baseline, as-built	446,448	--	--	--	--	--	--	--
2. Adjusted baseline	462,845	—	--	--	--	--	--	--
3. Seasonal heating and cooling	450,826	3	3	302	15.0	22,778	2.059	-24
4. Night setback in lobbies	460,896	1	1	49	15.0	3,695	2.666	-6
5. Demand control	447,244	3	5	392	15.0	29,567	2.261	-37
6. Evaporative cooling	469,612	-1	0	-170	--	--	--	--
7. Combine options 3 and 5	440,000	5	7	574	15.0	43,294	2.169	-51
8. Combine options 3, 5, and 6	408,756	12	15	1,359	15.0	102,504	3.162	-222

TABLE B-VI

ECONOMIC SUMMARY OF SOLAR OPTIONS FOR AERONAUTICS LABORATORY

Option	Estimated Energy Use ($Btu/ft^2/yr$)	% Energy Reduction	Estimated Annual Savings $1,000	Estimated Annual Savings 10^6 Btu	10^6 Btu Saved per $1000 Invested	Maximum Investment ($)	Discounted Benefit/ Cost Ratio	Life-Cycle Cost ($1,000)
1. Adjusted baseline	462,846	--	--	--	--	--	--	--
2. Daylighting	445,692	4	1	431	108.6	4,489	1.0	0
3. Trombe wall	452,896	2	3	250	15.0	18,857	2.846	-35
4. Sunspace for test cell classrooms	460,856	1	1	50	15.0	3,771	3.244	-8
5. Active solar heating 6,000 ft^2, 10,800 gal.	423,920	8	13	978	15.0	73,766	3.640	195
6. Solar DHW, 120 ft^2, 215 gal.	461,134	1	0	43	24.1	2,021	1.000	0

FORM A-1

ECIP ECONOMIC ANALYSIS SUMMARY

Location: Colorado Springs, [illegible] FY 84
Project: Vandenberg Hall
Reinsulate [illegible]
Economic Life: 15 Yrs. Date Prepared 7/82 Prepared by [illegible]

COSTS

1. Non-recurring Initial Capital Costs:
   a. CWE $ 9,696
   b. Design $ 1,327
   c. Salvage $ 0
   d. Total $ 11,023

BENEFITS

2. Recurring Benefit/Cost Differential Other Than Energy:
   a. Annual Labor Decrease (+)/Increase (-) $ −219 /Yr.
   b. Annual Material Decrease (+)/Increase (-) $ ___ /Yr.
   c. Other Annual Decrease (+)/Increase (-) $ ___ /Yr.
   d. Total Costs $ −219 /Yr.
   e. 10% Discount Factor $ 7.980
   f. Discounted Recurring Cost (d x e) $ −1748
3. Recurring Energy Benefit/Costs:
   a. Type of Fuel: Fuel Oil
      (1) Annual Energy Decrease (+)/Increase(-) −4.[illegible] MBTU
      (2) Cost per MBTU $ [illegible] /MBTU
      (3) Annual Dollar Decrease/Increase ((1)x(2)) $ −[illegible] /Yr.
      (4) Differential Escalation Rate (8 %) Factor [illegible]
      (5) Discounted Dollar Decrease/Increase(3)x(4) $ −7[illegible]
   b. Type of Fuel: Electricity
      (1) Annual Energy Decrease (+)/Increase (-) [illegible] MBTU
      (2) Cost per MBTU $ 3.07 /MBTU
      (3) Annual Dollar Decrease/Increase ((1)X(2)) $ 1099 /Yr.
      (4) Differential Escalation Rate (7 %) Factor [illegible]
      (5) Discounted Dollar Decrease/Increase ((3)x(4)) $ 13,494
   c. Type of Fuel: ___
      (1) Annual Energy Decrease (+)/Increase (-) ___ MBTU
      (2) Cost per MBTU $ ___ /MBTU
      (3) Annual Dollar Decrease/Increase ((1)x(2)) $ ___ /Yr.
      (4) Differential Escalation Rate (__%) Factor ___
      (5) Discounted Dollar Decrease/Increase ((3)x(4)) $ ___
   d. Type of Fuel: ___
      (1) Annual Energy Decrease (+)/Increase (-) ___ MBTU
      (2) Cost per MBTU $ ___ /MBTU
      (3) Annual Dollar Decrease/Increase ((1)x(2)) $ ___ /Yr.
      (4) Differential Escalation Rate (__%) Factor ___
      (5) Discounted Dollar Decrease/Increase ((3)x(4)) $ ___
   e. Discounted Energy Benefits (3a(5)+3b(5)+3c(5)+3d(5)) $ 12,771
4. Total Benefits (Sum 2f+3e) $ 11,023
5. Discounted Benefit/Cost Ratio (Line 4÷Line 1d) 1.000
6. Total Annual Energy Savings (3a(1)+3b(1)+3c(1)+3d(1)) 354 MBtu
7. E/C Ratio (Line 6 ÷ Line 1a/1000) 36.5
8. Annual $ Savings (2d+3a(3)+3b(3)+3c(3)+3d(3)) $ 825
9. Pay-back Period ((Line 1a − Salvage)÷Line 8) 11.75 yr
10. Life-Cycle Cost (Line [illegible]) $ 0

FORM A-1

ECIP ECONOMIC ANALYSIS SUMMARY

Location: Colorado Springs, CO FY 84
Project: Vandenberg Hall
Zone Thermostats for Baseboard Htg.
Economic Life: 15 Yrs. Date Prepared 9/82 Prepared by JLP

COSTS

1. Non-recurring Initial Capital Costs:
   a. CWE $ 211,467
   b. Design $ 25,145
   c. Salvage $ 0
   d. Total $ 236,612

BENEFITS

2. Recurring Benefit/Cost Differential Other Than Energy:
   a. Annual Labor Decrease (+)/Increase (-) $ -4,191 /Yr.
   b. Annual Material Decrease (+)/Increase (-) $ 0 /Yr.
   c. Other Annual Decrease (+)/Increase (-) $ 0 /Yr.
   d. Total Costs $ -4,191 /Yr.
   e. 10% Discount Factor $ 7.980
   f. Discounted Recurring Cost (d x e) $ - 33,444
3. Recurring Energy Benefit/Costs:
   a. Type of Fuel: Fuel Oil
      (1) Annual Energy Decrease (+)/Increase(-) 2,639 MBTU
      (2) Cost per MBTU $ 13.72 /MBTU
      (3) Annual Dollar Decrease/Increase ((1)x(2)) $ 36,367 /Yr.
      (4) Differential Escalation Rate (8 %) Factor 13.117
      (5) Discounted Dollar Decrease/Increase(3)x(4) $ 476,518
   b. Type of Fuel: Electricity
      (1) Annual Energy Decrease (+)/Increase (-) 533 MBTU
      (2) Cost per MBTU $ 3.07 /MBTU
      (3) Annual Dollar Decrease/Increase ((1)x(2)) $ 1636 /Yr.
      (4) Differential Escalation Rate (7 %) Factor 12.279
      (5) Discounted Dollar Decrease/Increase ((3)x(4)) $ 20,086
   c. Type of Fuel: ____
      (1) Annual Energy Decrease (+)/Increase (-) ____ MBTU
      (2) Cost per MBTU $ ____ /MBTU
      (3) Annual Dollar Decrease/Increase ((1)x(2)) $ ____ /Yr.
      (4) Differential Escalation Rate (__%) Factor ____
      (5) Discounted Dollar Decrease/Increase ((3)x(4)) $ ____
   d. Type of Fuel: ____
      (1) Annual Energy Decrease (+)/Increase (-) ____ MBTU
      (2) Cost per MBTU $ ____ /MBTU
      (3) Annual Dollar Decrease/Increase ((1)x(2)) $ ____ /Yr.
      (4) Differential Escalation Rate (__%) Factor ____
      (5) Discounted Dollar Decrease/Increase ((3)x(4)) $ ____
   e. Discounted Energy Benefits (3a(5)+3b(5)+3c(5)+3d(5)) $ 496,904
4. Total Benefits (Sum 2f+3e) $ 463,460
5. Discounted Benefit/Cost Ratio (Line 4÷Line 1d) 1.959
6. Total Annual Energy Savings (3a(1)+3b(1)+3c(1)+3d(1)) 3172 MBtu
7. E/C Ratio (Line 6 ÷ Line 1a/1000) 15.0
8. Annual $ Savings (2d+3a(3)+3b(3)+3c(3)+3d(3)) $ 33,810
9. Pay-back Period ((Line 1a - Salvage)÷Line 8) 6.25 yr
10. Life-Cycle Cost (Line 1d - 2f - 3e) $ - 226,848

FORM A-1

ECIP ECONOMIC ANALYSIS SUMMARY

Location: Colorado Springs, CO   FY 84
Project: [illegible] Hall
Tunnel Preheat of Ventilation Air
Economic Life: 25 Yrs.   Date Prepared 9/82   Prepared by JLP

COSTS

1. Non-recurring Initial Capital Costs:
   - a. CWE — $ 197,067
   - b. Design — $ 25,650
   - c. Salvage — $ 0
   - d. Total — $ 222,717

BENEFITS

2. Recurring Benefit/Cost Differential Other Than Energy:
   - a. Annual Labor Decrease (+)/Increase (-) — $ -4,274 /Yr.
   - b. Annual Material Decrease (+)/Increase (-) — $ 0 /Yr.
   - c. Other Annual Decrease (+)/Increase (-) — $ 0 /Yr.
   - d. Total Costs — $ -4,274 /Yr.
   - e. 10% Discount Factor — $ 9.524
   - f. Discounted Recurring Cost (d x e) — $ -40,7[illegible]
3. Recurring Energy Benefit/Costs:
   - a. Type of Fuel: Fuel Oil
     - (1) Annual Energy Decrease (+)/Increase(-) — 2,381 MBTU
     - (2) Cost per MBTU — $ 12.75 /MBTU
     - (3) Annual Dollar Decrease/Increase ((1)x(2)) — $ 29,705 /Yr.
     - (4) Differential Escalation Rate (5 %) Factor — [illegible] 050
     - (5) Discounted Dollar Decrease/Increase(3)x(4) — $ [illegible]
   - b. Type of Fuel: Electricity
     - (1) Annual Energy Decrease (+)/Increase (-) — 75 MBTU
     - (2) Cost per MBTU — $ 3.07 /MBTU
     - (3) Annual Dollar Decrease/Increase ((1)X(2)) — $ 230 /Yr.
     - (4) Differential Escalation Rate (7 %) Factor — 18.[illegible]
     - (5) Discounted Dollar Decrease/Increase ((3)x(4)) — $ 4,151
   - c. Type of Fuel: ______
     - (1) Annual Energy Decrease (+)/Increase (-) — ______ MBTU
     - (2) Cost per MBTU — $ ______ /MBTU
     - (3) Annual Dollar Decrease/Increase ((1)x(2)) — $ ______ /Yr.
     - (4) Differential Escalation Rate (__%) Factor — ______
     - (5) Discounted Dollar Decrease/Increase ((3)x(4)) — $ ______
   - d. Type of Fuel: ______
     - (1) Annual Energy Decrease (+)/Increase (-) — ______ MBTU
     - (2) Cost per MBTU — $ ______ /MBTU
     - (3) Annual Dollar Decrease/Increase ((1)x(2)) — $ ______ /Yr.
     - (4) Differential Escalation Rate (__%)Factor — ______
     - (5) Discounted Dollar Decrease/Increase ((3)x(4)) — $ ______
   - e. Discounted Energy Benefits (3a(5)+3b(5)+3c(5)+3d(5)) — $ 800,136
4. Total Benefits (Sum 2f+3e) — $ 757,430
5. Discounted Benefit/Cost Ratio (Line 4÷Line 1d) — 3.410
6. Total Annual Energy Savings (3a(1)+3b(1)+3c(1)+3d(1)) — 2,456 MBtu
7. E/C Ratio (Line 6 ÷ Line 1a/1000) — 15.0
8. Annual $ Savings (2d+3a(3)+3b(3)+3c(3)+3d(3)) — $ 25,656
9. Pay-back Period ((Line 1a - Salvage)÷Line 8) — 5.53 yr
10. Life-Cycle Cost (Line 1d - 2f - 3e) — $ -536,713

FORM A-1

ECIP ECONOMIC ANALYSIS SUMMARY

Location: Colorado Springs Co FY 86
Project: Vandenberg Hall
Reinstate Radiant Heating
Economic Life: 25 Yrs. Date Prepared 9/82 Prepared by JLP

COSTS

1. Non-recurring Initial Capital Costs:
   a. CWE $ 6,596
   b. Design $ 867
   c. Salvage $ 0
   d. Total $ 7,463

BENEFITS

2. Recurring Benefit/Cost Differential Other Than Energy:
   a. Annual Labor Decrease (+)/Increase (-) $ -144 /Yr.
   b. Annual Material Decrease (+)/Increase (-) $ 0 /Yr.
   c. Other Annual Decrease (+)/Increase (-) $ 0 /Yr.
   d. Total Costs $ -144 /Yr.
   e. 10% Discount Factor $ 9.524
   f. Discounted Recurring Cost (d x e) $ -1,372
3. Recurring Energy Benefit/Costs:
   a. Type of Fuel: Fuel Oil
      (1) Annual Energy Decrease (+)/Increase(-) -317 MBTU
      (2) Cost per MBTU $ 13.78 /MBTU
      (3) Annual Dollar Decrease/Increase ((1)x(2)) $ -4,368 /Yr.
      (4) Differential Escalation Rate (8 %) Factor 20.050
      (5) Discounted Dollar Decrease/Increase (3)x(4) $ -87,578
   b. Type of Fuel: Electricity
      (1) Annual Energy Decrease (+)/Increase (-) 1,740 MBTU
      (2) Cost per MBTU $ 3.07 /MBTU
      (3) Annual Dollar Decrease/Increase ((1)x(2)) $ 5,342 /Yr.
      (4) Differential Escalation Rate (7 %) Factor 18.044
      (5) Discounted Dollar Decrease/Increase ((3)x(4)) $ 96,418
   c. Type of Fuel:
      (1) Annual Energy Decrease (+)/Increase (-) MBTU
      (2) Cost per MBTU $ /MBTU
      (3) Annual Dollar Decrease/Increase ((1)x(2)) $ /Yr.
      (4) Differential Escalation Rate (_%) Factor
      (5) Discounted Dollar Decrease/Increase ((3)x(4)) $
   d. Type of Fuel:
      (1) Annual Energy Decrease (+)/Increase (-) MBTU
      (2) Cost per MBTU $ /MBTU
      (3) Annual Dollar Decrease/Increase ((1)x(2)) $ /Yr.
      (4) Differential Escalation Rate (_%)Factor
      (5) Discounted Dollar Decrease/Increase ((3)x(4)) $
   e. Discounted Energy Benefits (3a(5)+3b(5)+3c(5)+3d(5)) $ 8,840
4. Total Benefits (Sum 2f+3e) $ 7,468
5. Discounted Benefit/Cost Ratio (Line 4÷Line 1d) 1.000
6. Total Annual Energy Savings (3a(1)+3b(1)+3c(1)+3d(1)) 1423 mbtu
7. E/C Ratio (Line 6 ÷ Line 1a/1000) 215.7
8. Annual $ Savings (2d+3a(3)+3b(3)+3c(3)+3d(3)) $ 830
9. Pay-back Period ((Line 1a - Salvage)÷Line 8) 7.75 yr
10. Life-Cycle Cost (Line 1d-2f-3e) 0

FORM A-1

ECIP ECONOMIC ANALYSIS SUMMARY

Location: Colorado Springs, CO FY 1984
Project: Vandenberg Hall
Run-Around Heat Recovery Loop
Economic Life: 25 Yrs. Date Prepared 2/82 Prepared by T.P.

COSTS

1. Non-recurring Initial Capital Costs:
   a. CWE $ 1,343,467
   b. Design $ 174,500
   c. Salvage $ 0
   d. Total $ 1,517,967

BENEFITS

2. Recurring Benefit/Cost Differential Other Than Energy:
   a. Annual Labor Decrease (+)/Increase (-) $-29,082 /Yr.
   b. Annual Material Decrease (+)/Increase (-) $ 0 /Yr.
   c. Other Annual Decrease (+)/Increase (-) $ 0 /Yr.
   d. Total Costs $-29,082 /Yr.
   e. 10% Discount Factor $ 9.524
   f. Discounted Recurring Cost (d x e) $-276,986
3. Recurring Energy Benefit/Costs:
   a. Type of Fuel: Fuel Oil
      (1) Annual Energy Decrease (+)/Increase (-) 19,540 MBTU
      (2) Cost per MBTU $ 13.72 /MBTU
      (3) Annual Dollar Decrease/Increase ((1)x(2)) $ 264,661 /Yr.
      (4) Differential Escalation Rate (8 %) Factor 20.050
      (5) Discounted Dollar Decrease/Increase (3)x(4) $ 5,398,683
   b. Type of Fuel: Electricity
      (1) Annual Energy Decrease (+)/Increase (-) 612 MBTU
      (2) Cost per MBTU $ 3.07 /MBTU
      (3) Annual Dollar Decrease/Increase ((1)X(2)) $ 1879 /Yr.
      (4) Differential Escalation Rate (7 %) Factor 18.049
      (5) Discounted Dollar Decrease/Increase ((3)x(4)) $ 33,914
   c. Type of Fuel:
      (1) Annual Energy Decrease (+)/Increase (-) MBTU
      (2) Cost per MBTU $ /MBTU
      (3) Annual Dollar Decrease/Increase ((1)x(2)) $ /Yr.
      (4) Differential Escalation Rate (%) Factor
      (5) Discounted Dollar Decrease/Increase ((3)x(4)) $
   d. Type of Fuel:
      (1) Annual Energy Decrease (+)/Increase (-) MBTU
      (2) Cost per MBTU $ /MBTU
      (3) Annual Dollar Decrease/Increase ((1)x(2)) $ /Yr.
      (4) Differential Escalation Rate (%)Factor
      (5) Discounted Dollar Decrease/Increase ((3)x(4)) $
   e. Discounted Energy Benefits (3a(5)+3b(5)+3c(5)+3d(5)) $ 5,432,597
4. Total Benefits (Sum 2f+3e) $ 5,155,611
5. Discounted Benefit/Cost Ratio (Line 4÷Line 1d) 3.396
6. Total Annual Energy Savings (3a(1)+3b(1)+3c(1)+3d(1)) 20,152 MBtu
7. E/C Ratio (Line 6 ÷ Line 1a/1000) 15.0
8. Annual $ Savings (2d+3a(3)+3b(3)+3c(3)+3d(3)) $ 247,057
9. Pay-back Period ((Line 1a - Salvage)÷Line 8) 5.55 yr
10. Life-Cycle Cost (Line 1d - 2f - 3e) $ - 3,637,644

FORM A-1

ECIP ECONOMIC ANALYSIS SUMMARY

Location: Colorado Springs FY 84
Project: Vandenberg Hall
Minimize Ventilation Rates
Economic Life: 25 Yrs. Date Prepared 9/83 Prepared by JLP

COSTS

1. Non-recurring Initial Capital Costs:
   - a. CWE $ 885,844
   - b. Design $ 115,516
   - c. Salvage $ 0
   - d. Total $ 1,001,360

BENEFITS

2. Recurring Benefit/Cost Differential Other Than Energy:
   - a. Annual Labor Decrease (+)/Increase (-) $ -19,395 /Yr.
   - b. Annual Material Decrease (+)/Increase (-) $ 0 /Yr.
   - c. Other Annual Decrease (+)/Increase (-) $ 0 /Yr.
   - d. Total Costs $ -19,395 /Yr.
   - e. 10% Discount Factor $ 9.524
   - f. Discounted Recurring Cost (d x e) $ -184,747
3. Recurring Energy Benefit/Costs:
   - a. Type of Fuel: Fuel Oil
     - (1) Annual Energy Decrease (+)/Increase(-) 1[illegible] 977 MBTU
     - (2) Cost per MBTU $ 1[illegible].76 /MBTU
     - (3) Annual Dollar Decrease/Increase ((1)x(2)) $ 175,[illegible] /Yr.
     - (4) Differential Escalation Rate (8 %)Factor 20.650
     - (5) Discounted Dollar Decrease/Increase(3)x(4) $ 3,[illegible]
   - b. Type of Fuel: Electricity
     - (1) Annual Energy Decrease (+)/Increase (-) 310 MBTU
     - (2) Cost per MBTU $ [illegible] /MBTU
     - (3) Annual Dollar Decrease/Increase ((1)X(2)) $ [illegible] /Yr.
     - (4) Differential Escalation Rate (7 %) Factor 18.049
     - (5) Discounted Dollar Decrease/Increase ((3)x(4)) $ 17,1[illegible]
   - c. Type of Fuel: ______
     - (1) Annual Energy Decrease (+)/Increase (-) ______ MBTU
     - (2) Cost per MBTU $ ______ /MBTU
     - (3) Annual Dollar Decrease/Increase ((1)x(2)) $ ______ /Yr.
     - (4) Differential Escalation Rate (__%) Factor ______
     - (5) Discounted Dollar Decrease/Increase ((3)x(4)) $ ______
   - d. Type of Fuel: ______
     - (1) Annual Energy Decrease (+)/Increase (-) ______ MBTU
     - (2) Cost per MBTU $ ______ /MBTU
     - (3) Annual Dollar Decrease/Increase ((1)x(2)) $ ______ /Yr.
     - (4) Differential Escalation Rate (__%)Factor ______
     - (5) Discounted Dollar Decrease/Increase ((3)x(4)) $ ______
   - e. Discounted Energy Benefits (3a(5)+3b(5)+3c(5)+3d(5)) $ 3,6[illegible],583
4. Total Benefits (Sum 2f+3e) $ 3,417,836
5. Discounted Benefit/Cost Ratio (Line 4÷Line 1d) 3.413
6. Total Annual Energy Savings (3a(1)+3b(1)+3c(1)+3d(1)) 12,287 MBtu
7. E/C Ratio (Line 6 ÷ Line 1a/1000) 15.0
8. Annual $ Savings (2d+3a(3)+3b(3)+3c(3)+3d(3)) $ 160,377
9. Pay-back Period ((Line 1a - Salvage)÷Line 8) 5.52 yr
10. Life-cycle Cost (Line 1d - 2f - 3e) $ -2,416,476

FORM A-1

ECIP ECONOMIC ANALYSIS SUMMARY

Location: [illegible] FY [illegible]
Project: [illegible]
[illegible]
Economic Life: [illegible] Yrs. Date Prepared [illegible] Prepared by [illegible]

COSTS

1. Non-recurring Initial Capital Costs:
   a. CWE $ 194 420
   b. Design $ [illegible]
   c. [illegible] $ 0
   d. Total $ 220,150

BENEFITS

2. Recurring Benefit/Cost Differential Other Than Energy:
   a. Annual Labor Decrease (+)/Increase (-) $ -4 296 /Yr.
   b. Annual Material Decrease (+)/Increase (-) $ 0 /Yr.
   c. Other Annual Decrease (+)/Increase (-) $ 0 /Yr.
   d. Total Costs $ -4 299 /Yr.
   e. 10% Discount Factor $ [illegible]
   f. Discounted Recurring Cost (d x e) $ -40,839
3. Recurring Energy Benefit/Costs:
   a. Type of Fuel: [illegible]
      (1) Annual Energy Decrease (+)/Increase(-) 0 MBTU
      (2) Cost per MBTU $ [illegible] /MBTU
      (3) Annual Dollar Decrease/Increase ((1)x(2)) $ 0 /Yr.
      (4) Differential Escalation Rate ([illegible] %)Factor [illegible]
      (5) Discounted Dollar Decrease/Increase(3)x(4) $ 0
   b. Type of Fuel: [illegible]
      (1) Annual Energy Decrease (+)/Increase (-) 4 710 MBTU
      (2) Cost per MBTU $ 3.07 /MBTU
      (3) Annual Dollar Decrease/Increase ((1)X(2)) $ 14 460 /Yr.
      (4) Differential Escalation Rate (7 %) Factor 18.[illegible]
      (5) Discounted Dollar Decrease/Increase ((3)x(4)) $ 260 989
   c. Type of Fuel:
      (1) Annual Energy Decrease (+)/Increase (-) MBTU
      (2) Cost per MBTU $ /MBTU
      (3) Annual Dollar Decrease/Increase ((1)x(2)) $ /Yr.
      (4) Differential Escalation Rate (_%) Factor
      (5) Discounted Dollar Decrease/Increase ((3)x(4)) $
   d. Type of Fuel:
      (1) Annual Energy Decrease (+)/Increase (-) MBTU
      (2) Cost per MBTU $ /MBTU
      (3) Annual Dollar Decrease/Increase ((1)x(2)) $ /Yr.
      (4) Differential Escalation Rate (_%)Factor
      (5) Discounted Dollar Decrease/Increase ((3)x(4)) $
   e. Discounted Energy Benefits (3a(5)+3b(5)+3c(5)+3d(5)) $ 260,989
4. Total Benefits (Sum 2f+3e) $ 220,150
5. Discounted Benefit/Cost Ratio (Line 4÷Line 1d) 1.000
6. Total Annual Energy Savings (3a(1)+3b(1)+3c(1)+3d(1)) 4,710 MBtu
7. E/C Ratio (Line 6 ÷ Line 1a/1000) 24.2
8. Annual $ Savings (2d+3a(3)+3b(3)+3c(3)+3d(3)) $ 10,172
9. Pay-back Period ((Line 1a - Salvage)÷Line 8) 19.1 yr
10. Life-Cycle Cost (Line 1d - 2f - 3e) $ - 0

FORM A-1

ECIP ECONOMIC ANALYSIS SUMMARY

Location: Colorado Springs FY 84
Project: Vandenberg Hall
Night Insulation for Windows
Economic Life: 25 Yrs. Date Prepared 9/83 Prepared by [illegible]

COSTS

1. Non-recurring Initial Capital Costs:
   a. CWE $ [illegible]
   b. Design $ [illegible]
   c. Salvage $ [illegible]
   d. Total $ [illegible]

BENEFITS

2. Recurring Benefit/Cost Differential Other Than Energy:
   a. Annual Labor Decrease (+)/Increase (-) $ -1,024 /Yr.
   b. Annual Material Decrease (+)/Increase (-) $ 0 /Yr.
   c. Other Annual Decrease (+)/Increase (-) $ 0 /Yr.
   d. Total Costs $ -1,024 /Yr.
   e. 10% Discount Factor $ 9.524
   f. Discounted Recurring Cost (d x e) $ -9,753
3. Recurring Energy Benefit/Costs:
   a. Type of Fuel: Fuel Oil
      (1) Annual Energy Decrease (+)/Increase(-) 610 MBTU
      (2) Cost per MBTU $ 13.76 /MBTU
      (3) Annual Dollar Decrease/Increase ((1)x(2)) $ [illegible] /Yr.
      (4) Differential Escalation Rate (8 %) Factor [illegible]
      (5) Discounted Dollar Decrease/Increase (3)x(4) $ [illegible]
   b. Type of Fuel: Electricity
      (1) Annual Energy Decrease (+)/Increase (-) 18 MBTU
      (2) Cost per MBTU $ [illegible] /MBTU
      (3) Annual Dollar Decrease/Increase ((1)X(2)) $ 55.26 /Yr.
      (4) Differential Escalation Rate (7 %) Factor [illegible]
      (5) Discounted Dollar Decrease/Increase ((3)x(4)) $ [illegible]
   c. Type of Fuel:
      (1) Annual Energy Decrease (+)/Increase (-) MBTU
      (2) Cost per MBTU $ /MBTU
      (3) Annual Dollar Decrease/Increase ((1)x(2)) $ /Yr.
      (4) Differential Escalation Rate (%) Factor
      (5) Discounted Dollar Decrease/Increase ((3)x(4)) $
   d. Type of Fuel:
      (1) Annual Energy Decrease (+)/Increase (-) MBTU
      (2) Cost per MBTU $ /MBTU
      (3) Annual Dollar Decrease/Increase ((1)x(2)) $ /Yr.
      (4) Differential Escalation Rate (%) Factor
      (5) Discounted Dollar Decrease/Increase ((3)x(4)) $
   e. Discounted Energy Benefits (3a(5)+3b(5)+3c(5)+3d(5)) $ 191,632
4. Total Benefits (Sum 2f+3e) $ 181,879
5. Discounted Benefit/Cost Ratio (Line 4÷Line 1d) 3.410
6. Total Annual Energy Savings (3a(1)+3b(1)+3c(1)+3d(1)) 709 MBTU
7. E/C Ratio (Line 6 ÷ Line 1a/1000) [illegible]
8. Annual $ Savings (2d+3a(3)+3b(3)+3c(3)+3d(3)) $ [illegible]
9. Pay-back Period ((Line 1a - Salvage)÷Line 8) 5.53 yrs
10. Life-Cycle Cost (Line 1d-2f-3e) $ -126,537

FORM A-1

ECIP ECONOMIC ANALYSIS SUMMARY

Location: Colorado Springs, CO FY 84
Project: Air Force Academy
Improve Wall and Roof Insulation
Economic Life: 25 Yrs. Date Prepared 9/21 Prepared by JLP

COSTS

1. Non-recurring Initial Capital Costs:
   - a. CWE $ 15,??7
   - b. Design $ 1,221
   - c. Salvage $ 0
   - d. Total $ 17,065

BENEFITS

2. Recurring Benefit/Cost Differential Other Than Energy:
   - a. Annual Labor Decrease (+)/Increase (-) $ -360 /Yr.
   - b. Annual Material Decrease (+)/Increase (-) $ 0 /Yr.
   - c. Other Annual Decrease (+)/Increase (-) $ 0 /Yr.
   - d. Total Costs $ -360 /Yr.
   - e. 10% Discount Factor $ 9.524
   - f. Discounted Recurring Cost (d x e) $ -3,429
3. Recurring Energy Benefit/Costs:
   - a. Type of Fuel: Fuel Oil
     - (1) Annual Energy Decrease (+)/Increase(-) 276 MBTU
     - (2) Cost per MBTU $ 13.78 /MBTU
     - (3) Annual Dollar Decrease/Increase ((1)x(2)) $ 3,803 /Yr.
     - (4) Differential Escalation Rate (5 %)Factor 20.050
     - (5) Discounted Dollar Decrease/Increase(3)x(4) $ 76,250
   - b. Type of Fuel: Electricity
     - (1) Annual Energy Decrease (+)/Increase (-) -47 MBTU
     - (2) Cost per MBTU $ 3.07 /MBTU
     - (3) Annual Dollar Decrease/Increase ((1)X(2)) $ -144 /Yr.
     - (4) Differential Escalation Rate (7 %) Factor 18.049
     - (5) Discounted Dollar Decrease/Increase ((3)x(4)) $ -2,599
   - c. Type of Fuel: ____
     - (1) Annual Energy Decrease (+)/Increase (-) ____ MBTU
     - (2) Cost per MBTU $ ____ /MBTU
     - (3) Annual Dollar Decrease/Increase ((1)x(2)) $ ____ /Yr.
     - (4) Differential Escalation Rate (__%) Factor ____
     - (5) Discounted Dollar Decrease/Increase ((3)x(4)) $ ____
   - d. Type of Fuel: ____
     - (1) Annual Energy Decrease (+)/Increase (-) ____ MBTU
     - (2) Cost per MBTU $ ____ /MBTU
     - (3) Annual Dollar Decrease/Increase ((1)x(2)) $ ____ /Yr.
     - (4) Differential Escalation Rate (__%)Factor ____
     - (5) Discounted Dollar Decrease/Increase ((3)x(4)) $ ____
   - e. Discounted Energy Benefits (3a(5)+3b(5)+3c(5)+3d(5)) $ 73,651
4. Total Benefits (Sum 2f+3e) $ 70,222
5. Discounted Benefit/Cost Ratio (Line 4÷Line 1d) 4.114
6. Total Annual Energy Savings (3a(1)+3b(1)+3c(1)+3d(1)) 229
7. E/C Ratio (Line 6 ÷ Line 1a/1000) 15.0
8. Annual $ Savings (2d+3a(3)+3b(3)+3c(3)+3d(3)) $ 3,299
9. Pay-back Period ((Line 1a - Salvage)÷Line 8) 4.63
10. Life-Cycle Cost (Line 1d - 2f - 3e) $ -53,154

FORM A-1

ECIP ECONOMIC ANALYSIS SUMMARY

Location: Colorado Springs, CO   FY 84
Project: [illegible] Hall
6 and 7
Economic Life: 25 Yrs.   Date Prepared 10/81   Prepared by JLP

COSTS	
1. Non-recurring Initial Capital Costs:	
a. CWE	$1,517,676
b. Design	$197,910
c. Salvage	$0
d. Total	$1,715,586
BENEFITS	
2. Recurring Benefit/Cost Differential Other Than Energy:	
a. Annual Labor Decrease (+)/Increase (-)	$-22,234 /Yr.
b. Annual Material Decrease (+)/Increase (-)	$0 /Yr.
c. Other Annual Decrease (+)/Increase (-)	$0 /Yr.
d. Total Costs	$-22,234 /Yr.
e. 10% Discount Factor	$9.524
f. Discounted Recurring Cost (d x e)	$[illegible]
3. Recurring Energy Benefit/Costs:	
a. Type of Fuel: Fuel Oil	
(1) Annual Energy Decrease (+)/Increase (-)	22,115 MBTU
(2) Cost per MBTU	$12.[illegible] /MBTU
(3) Annual Dollar Decrease/Increase ((1)x(2))	$[illegible]4,745 /Yr.
(4) Differential Escalation Rate (6 %) Factor	[illegible]
(5) Discounted Dollar Decrease/Increase (3)x(4)	$[illegible]
b. Type of Fuel: Electricity	
(1) Annual Energy Decrease (+)/Increase (-)	649 MBTU
(2) Cost per MBTU	$3.07 /MBTU
(3) Annual Dollar Decrease/Increase ((1)X(2))	$1,992 /Yr.
(4) Differential Escalation Rate (7 %) Factor	18.049
(5) Discounted Dollar Decrease/Increase ((3)x(4))	$35,961
c. Type of Fuel:	
(1) Annual Energy Decrease (+)/Increase (-)	MBTU
(2) Cost per MBTU	$ /MBTU
(3) Annual Dollar Decrease/Increase ((1)x(2))	$ /Yr.
(4) Differential Escalation Rate (%) Factor	
(5) Discounted Dollar Decrease/Increase ((3)x(4))	$
d. Type of Fuel:	
(1) Annual Energy Decrease (+)/Increase (-)	MBTU
(2) Cost per MBTU	$ /MBTU
(3) Annual Dollar Decrease/Increase ((1)x(2))	$ /Yr.
(4) Differential Escalation Rate (%) Factor	
(5) Discounted Dollar Decrease/Increase ((3)x(4))	$
e. Discounted Energy Benefits (3a(5)+3b(5)+3c(5)+3d(5))	$6,146,092
4. Total Benefits (Sum 2f+3e)	$5,829,571
5. Discounted Benefit/Cost Ratio (Line 4÷Line 1d)	[illegible]
6. Total Annual Energy Savings (3a(1)+3b(1)+3c(1)+3d(1))	22,764 MBTU
7. E/C Ratio (Line 6 ÷ Line 1a/1000)	15.0
8. Annual $ Savings (2d+3a(3)+3b(3)+3c(3)+3d(3))	$[illegible]503
9. Pay-back Period ((Line 1a - Salvage)÷Line 8)	5.55 yr
10. Life-Cycle Cost (Line 1d - 2f - 3e)	-$4,112,965

FORM A-1

ECIP ECONOMIC ANALYSIS SUMMARY

Location: [illegible] FY 84
Project: [illegible]
Economic Life: 25 Yrs. Date Prepared [illegible] Prepared by [illegible]

COSTS

1. Non-recurring Initial Capital Costs:	
a. CWE	$ [illegible]
b. Design	$ [illegible]
c. Salvage	$ 0
d. Total	$ 1,125,466
BENEFITS	
2. Recurring Benefit/Cost Differential Other Than Energy:	
a. Annual Labor Decrease (+)/Increase (-)	$ -27,500 /Yr.
b. Annual Material Decrease (+)/Increase (-)	$ 0 /Yr.
c. Other Annual Decrease (+)/Increase (-)	$ 0 /Yr.
d. Total Costs	$ -27,502 /Yr.
e. 10% Discount Factor	$ 9.524
f. Discounted Recurring Cost (d x e)	$ -257,[illegible]
3. Recurring Energy Benefit/Costs:	
a. Type of Fuel: [illegible]	
(1) Annual Energy Decrease (+)/Increase (-)	[illegible] MBTU
(2) Cost per MBTU	$ [illegible] /MBTU
(3) Annual Dollar Decrease/Increase ((1)x(2))	$ [illegible] 745 /Yr.
(4) Differential Escalation Rate (__%) Factor	[illegible]
(5) Discounted Dollar Decrease/Increase (3)x(4)	$ [illegible]
b. Type of Fuel: Electricity	
(1) Annual Energy Decrease (+)/Increase (-)	[illegible] MBTU
(2) Cost per MBTU	$ [illegible] /MBTU
(3) Annual Dollar Decrease/Increase ((1)X(2))	$ [illegible] /Yr.
(4) Differential Escalation Rate (7 %) Factor	[illegible]
(5) Discounted Dollar Decrease/Increase ((3)x(4))	$ [illegible]
c. Type of Fuel:	
(1) Annual Energy Decrease (+)/Increase (-)	MBTU
(2) Cost per MBTU	$ /MBTU
(3) Annual Dollar Decrease/Increase ((1)x(2))	$ /Yr.
(4) Differential Escalation Rate (__%) Factor	
(5) Discounted Dollar Decrease/Increase ((3)x(4))	$
d. Type of Fuel:	
(1) Annual Energy Decrease (+)/Increase (-)	MBTU
(2) Cost per MBTU	$ /MBTU
(3) Annual Dollar Decrease/Increase ((1)x(2))	$ /Yr.
(4) Differential Escalation Rate (__%) Factor	
(5) Discounted Dollar Decrease/Increase ((3)x(4))	$
e. Discounted Energy Benefits (3a(5)+3b(5)+3c(5)+3d(5))	$ 6,40[illegible],131
4. Total Benefits (Sum 2f+3e)	$ 6,[illegible],460
5. Discounted Benefit/Cost Ratio (Line 4÷Line 1d)	3.125
6. Total Annual Energy Savings (3a(1)+3b(1)+3c(1)+3d(1))	27,475 MBtu
7. E/C Ratio (Line 6 ÷ Line 1a/1000)	16.043
8. Annual $ Savings (2d+3a(3)+3b(3)+3c(3)+3d(3))	$ 283,678
9. Pay-back Period ((Line 1a - Salvage)÷Line 8)	6.037 yr
10. Life-Cycle Cost (Line 1d-2f-3e)	-$ 4,113,994

FORM A-1

ECIP ECONOMIC ANALYSIS SUMMARY

Location: Colorado Springs, CO FY 84
Project: Vandenberg Hall
6, 7, 8 and 2
Economic Life: 25 Yrs. Date Prepared 9/82 Prepared by JLP

COSTS

1. Non-recurring Initial Capital Costs:
   - a. CWE $[illegible]
   - b. Design $[illegible] 706
   - c. Salvage $0
   - d. Total $1,447,720

BENEFITS

2. Recurring Benefit/Cost Differential Other Than Energy:
   - a. Annual Labor Decrease (+)/Increase (-) $-37,730 /Yr.
   - b. Annual Material Decrease (+)/Increase (-) $ 0 /Yr.
   - c. Other Annual Decrease (+)/Increase (-) $ 0 /Yr.
   - d. Total Costs $-37,730 /Yr.
   - e. 10% Discount Factor $ 9.524
   - f. Discounted Recurring Cost (d x e) $-35[illegible],226
3. Recurring Energy Benefit/Costs:
   - a. Type of Fuel: Fuel oil
     - (1) Annual Energy Decrease (+)/Increase(-) [illegible] MBTU
     - (2) Cost per MBTU $13.75 /MBTU
     - (3) Annual Dollar Decrease/Increase ((1)x(2)) $304,6[illegible] /Yr.
     - (4) Differential Escalation Rate (8 %)Factor 2[illegible].650
     - (5) Discounted Dollar Decrease/Increase(3)x(4) $6,167,270
   - b. Type of Fuel: Electricity
     - (1) Annual Energy Decrease (+)/Increase (-) 5,720 MBTU
     - (2) Cost per MBTU $3.07 /MBTU
     - (3) Annual Dollar Decrease/Increase ((1)x(2)) $17,5[illegible] /Yr.
     - (4) Differential Escalation Rate (7 %) Factor 12.[illegible]
     - (5) Discounted Dollar Decrease/Increase ((3)x(4)) $2[illegible]6,[illegible]40
   - c. Type of Fuel:
     - (1) Annual Energy Decrease (+)/Increase (-) MBTU
     - (2) Cost per MBTU $ /MBTU
     - (3) Annual Dollar Decrease/Increase ((1)x(2)) $ /Yr.
     - (4) Differential Escalation Rate (_%) Factor
     - (5) Discounted Dollar Decrease/Increase ((3)x(4)) $
   - d. Type of Fuel:
     - (1) Annual Energy Decrease (+)/Increase (-) MBTU
     - (2) Cost per MBTU $ /MBTU
     - (3) Annual Dollar Decrease/Increase ((1)x(2)) $ /Yr.
     - (4) Differential Escalation Rate (_%)Factor
     - (5) Discounted Dollar Decrease/Increase ((3)x(4)) $
   - e. Discounted Energy Benefits (3a(5)+3b(5)+3c(5)+3d(5)) $6,4[illegible]4,310
4. Total Benefits (Sum 2f+3e) $6,064,974
5. Discounted Benefit/Cost Ratio (Line 4÷Line 1d) [illegible].114
6. Total Annual Energy Savings (3a(1)+3b(1)+3c(1)+3d(1)) 27,885 mbtu
7. E/C Ratio (Line 6 ÷ Line 1a/1000) 16.149
8. Annual $ Savings (2d+3a(3)+3b(3)+3c(3)+3d(3)) $284,437
9. Pay-back Period ((Line 1a - Salvage)÷Line 8) 6.05[illegible] yr
10. Life-Cycle Cost (Line 1d-2f-3e) -$ 4,17,254

FORM A-1

ECIP ECONOMIC ANALYSIS SUMMARY

Location: [illegible] FY 84
Project: Air Force Academy
6, 7, 8, 2 and 3
Economic Life: [illegible] Yrs. Date Prepared [illegible] Prepared by [illegible]

COSTS

1. Non-recurring Initial Capital Costs:
   a. CWE $ [illegible]
   b. Design $ [illegible]
   c. [illegible] $ 0
   d. Total $ 2,124,552

BENEFITS

2. Recurring Benefit/Cost Differential Other Than Energy:
   a. Annual Labor Decrease (+)/Increase (-) $ -41,321 /Yr.
   b. Annual Material Decrease (+)/Increase (-) $ 0 /Yr.
   c. Other Annual Decrease (+)/Increase (-) $ 0 /Yr.
   d. Total Costs $ -41,321 /Yr.
   e. 10% Discount Factor $ [illegible]
   f. Discounted Recurring Cost (d x e) $ -[illegible],256
3. Recurring Energy Benefit/Costs:
   a. Type of Fuel: Fuel Oil
      (1) Annual Energy Decrease (+)/Increase (-) [illegible] MBTU
      (2) Cost per MBTU $ [illegible] /MBTU
      (3) Annual Dollar Decrease/Increase ((1)x(2)) $ [illegible] /Yr.
      (4) Differential Escalation Rate (_ %) Factor [illegible]
      (5) Discounted Dollar Decrease/Increase (3)x(4) $ [illegible]
   b. Type of Fuel: Electricity
      (1) Annual Energy Decrease (+)/Increase (-) 6,160 MBTU
      (2) Cost per MBTU $ [illegible] /MBTU
      (3) Annual Dollar Decrease/Increase ((1)X(2)) $ [illegible] /Yr.
      (4) Differential Escalation Rate (7 %) Factor [illegible]
      (5) Discounted Dollar Decrease/Increase ((3)x(4)) $ [illegible]
   c. Type of Fuel: ____
      (1) Annual Energy Decrease (+)/Increase (-) ____ MBTU
      (2) Cost per MBTU $ ____ /MBTU
      (3) Annual Dollar Decrease/Increase ((1)x(2)) $ ____ /Yr.
      (4) Differential Escalation Rate (__%) Factor ____
      (5) Discounted Dollar Decrease/Increase ((3)x(4)) $ ____
   d. Type of Fuel: ____
      (1) Annual Energy Decrease (+)/Increase (-) ____ MBTU
      (2) Cost per MBTU $ ____ /MBTU
      (3) Annual Dollar Decrease/Increase ((1)x(2)) $ ____ /Yr.
      (4) Differential Escalation Rate (__%) Factor ____
      (5) Discounted Dollar Decrease/Increase ((3)x(4)) $ ____
   e. Discounted Energy Benefits (3a(5)+3b(5)+3c(5)+3d(5)) $ 6,946,287
4. Total Benefits (Sum 2f+3e) $ 6,447,031
5. Discounted Benefit/Cost Ratio (Line 4÷Line 1d) 2.951
6. Total Annual Energy Savings (3a(1)+3b(1)+3c(1)+3d(1)) 39,72[illegible] MBtu
7. E/C Ratio (Line 6 ÷ Line 1a/1000) 15.4
8. Annual $ Savings (2d+3a(3)+3b(3)+3c(3)+3d(3)) $ 501,433
9. Pay-back Period ((Line 1a - Salvage)÷Line 8) 6.42 yr.
10. Life-Cycle [illegible] $ -4,262,649

FORM A-1

ECIP ECONOMIC ANALYSIS SUMMARY

Location: Colorado Springs CO FY 84
Project: Vandenberg Hall
Solar Domestic Hot Water System – 40,000 ft² Collector
Economic Life: 25 Yrs. Date Prepared 7/82 Prepared by JLP

COSTS

1. Non-recurring Initial Capital Costs:
   a. CWE $ 244,123
   b. Design $ 46,0[illegible]9
   c. Salvage $ 0
   d. Total $ 290,192

BENEFITS

2. Recurring Benefit/Cost Differential Other Than Energy:
   a. Annual Labor Decrease (+)/Increase (-) $ -7,6[illegible] /Yr.
   b. Annual Material Decrease (+)/Increase (-) $ 0 /Yr.
   c. Other Annual Decrease (+)/Increase (-) $ 0 /Yr.
   d. Total Costs $ -7,677 /Yr.
   e. 10% Discount Factor $ [illegible]524
   f. Discounted Recurring Cost (d x e) $ -7[illegible],116
3. Recurring Energy Benefit/Costs:
   a. Type of Fuel: Fuel Oil
      (1) Annual Energy Decrease (+)/Increase (-) 5,459 MBTU
      (2) Cost per MBTU $ 13.[illegible] /MBTU
      (3) Annual Dollar Decrease/Increase ((1)x(2)) $ 75,[illegible] /Yr.
      (4) Differential Escalation Rate (5 %) Factor [illegible]
      (5) Discounted Dollar Decrease/Increase (3)x(4) $ 1,508,261
   b. Type of Fuel: Electricity
      (1) Annual Energy Decrease (+)/Increase (-) -297 MBTU
      (2) Cost per MBTU $ 3.07 /MBTU
      (3) Annual Dollar Decrease/Increase ((1)X(2)) $ -912 /Yr.
      (4) Differential Escalation Rate (7 %) Factor 16.[illegible]
      (5) Discounted Dollar Decrease/Increase ((3)x(4)) $ -16,4[illegible]
   c. Type of Fuel: ____
      (1) Annual Energy Decrease (+)/Increase (-) ____ MBTU
      (2) Cost per MBTU $ ____ /MBTU
      (3) Annual Dollar Decrease/Increase ((1)x(2)) $ ____ /Yr.
      (4) Differential Escalation Rate (__%) Factor ____
      (5) Discounted Dollar Decrease/Increase ((3)x(4)) $ ____
   d. Type of Fuel: ____
      (1) Annual Energy Decrease (+)/Increase (-) ____ MBTU
      (2) Cost per MBTU $ ____ /MBTU
      (3) Annual Dollar Decrease/Increase ((1)x(2)) $ ____ /Yr.
      (4) Differential Escalation Rate (__%) Factor ____
      (5) Discounted Dollar Decrease/Increase ((3)x(4)) $ ____
   e. Discounted Energy Benefits (3a(5)+3b(5)+3c(5)+3d(5)) $ 1,491,900
4. Total Benefits (Sum 2f+3e) $ 1,418,684
5. Discounted Benefit/Cost Ratio (Line 4÷Line 1d) 3.626
6. Total Annual Energy Savings (3a(1)+3b(1)+3c(1)+3d(1)) 5,162 MBtu
7. E/C Ratio (Line 6 ÷ Line 1a/1000) 15.0
8. Annual $ Savings (2d+3a(3)+3b(3)+3c(3)+3d(3)) $ 66,636
9. Pay-back Period ((Line 1a - Salvage)÷Line 8) 5.16
10. Life-Cycle Cost (Line 1d - 2f - 3e) -$ 1,028,493

FORM A-1

ECIP ECONOMIC ANALYSIS SUMMARY

Location: Colorado Springs CO FY 84

Project: Field House

Utility Tunnel Heat Recovery

Economic Life: 25 Yrs. Date Prepared 9/82 Prepared by JLP

COSTS

1. Non-recurring Initial Capital Costs:
   - a. CWE $ 702,867
   - b. Design $ 92,347
   - c. Salvage $ 0
   - d. Total $ 795,214

BENEFITS

2. Recurring Benefit/Cost Differential Other Than Energy:
   - a. Annual Labor Decrease (+)/Increase (-) $ -15,391 /Yr.
   - b. Annual Material Decrease (+)/Increase (-) $ 0 /Yr.
   - c. Other Annual Decrease (+)/Increase (-) $ 0 /Yr.
   - d. Total Costs $ -15,391 /Yr.
   - e. 10% Discount Factor $ 9.524
   - f. Discounted Recurring Cost (d x e) $ -146,584
3. Recurring Energy Benefit/Costs:
   - a. Type of Fuel: Fuel Oil
     - (1) Annual Energy Decrease (+)/Increase(-) 10,543 MBTU
     - (2) Cost per MBTU $ 13.78 /MBTU
     - (3) Annual Dollar Decrease/Increase ((1)x(2)) $ 145,283 /Yr.
     - (4) Differential Escalation Rate (5 %)Factor 20.050
     - (5) Discounted Dollar Decrease/Increase(3)x(4) $ 2,912,924
   - b. Type of Fuel: Electricity
     - (1) Annual Energy Decrease (+)/Increase (-) 0 MBTU
     - (2) Cost per MBTU $ 5.27 /MBTU
     - (3) Annual Dollar Decrease/Increase ((1)X(2)) $ 0 /Yr.
     - (4) Differential Escalation Rate (7 %) Factor 12.549
     - (5) Discounted Dollar Decrease/Increase ((3)x(4)) $ 0
   - c. Type of Fuel: ____
     - (1) Annual Energy Decrease (+)/Increase (-) ____ MBTU
     - (2) Cost per MBTU $ ____ /MBTU
     - (3) Annual Dollar Decrease/Increase ((1)x(2)) $ ____ /Yr.
     - (4) Differential Escalation Rate (__%) Factor ____
     - (5) Discounted Dollar Decrease/Increase ((3)x(4)) $ ____
   - d. Type of Fuel: ____
     - (1) Annual Energy Decrease (+)/Increase (-) ____ MBTU
     - (2) Cost per MBTU $ ____ /MBTU
     - (3) Annual Dollar Decrease/Increase ((1)x(2)) $ ____ /Yr.
     - (4) Differential Escalation Rate (__%)Factor ____
     - (5) Discounted Dollar Decrease/Increase ((3)x(4)) $ ____
   - e. Discounted Energy Benefits (3a(5)+3b(5)+3c(5)+3d(5)) $ 2,912,924
4. Total Benefits (Sum 2f+3e) $ 2,766,340
5. Discounted Benefit/Cost Ratio (Line 4÷Line 1d) 3.479
6. Total Annual Energy Savings (3a(1)+3b(1)+3c(1)+3d(1)) 10,543
7. E/C Ratio (Line 6 ÷ Line 1a/1000) 15.0
8. Annual $ Savings (2d+3a(3)+3b(3)+3c(3)+3d(3)) $ 129,892
9. Pay-back Period ((Line 1a - Salvage)÷Line 8) 5.41
10. Life-cycle Cost (Line 1d - 2f - 3e) -$ 1,971,126

FORM A-1

ECIP ECONOMIC ANALYSIS SUMMARY

Location: Colorado Springs, CO FY 84

Project: Field House

Reduce Thermostat Setting

Economic Life: 15 Yrs. Date Prepared 9/82 Prepared by JP

COSTS

1. Non-recurring Initial Capital Costs:
   a. CWE $ [illegible]
   b. Design $ 41,[illegible]
   c. Salvage $ –
   d. Total $ 358,[illegible]

BENEFITS

2. Recurring Benefit/Cost Differential Other Than Energy:
   a. Annual Labor Decrease (+)/Increase (-) $ -6,934 /Yr.
   b. Annual Material Decrease (+)/Increase (-) $ 0 /Yr.
   c. Other Annual Decrease (+)/Increase (-) $ 0 /Yr.
   d. Total Costs $ -6,934 /Yr.
   e. 10% Discount Factor $ 7.980
   f. Discounted Recurring Cost (d x e) $ -55,[illegible]
3. Recurring Energy Benefit/Costs:
   a. Type of Fuel: Fuel Oil
      (1) Annual Energy Decrease (+)/Increase (-) [illegible] MBTU
      (2) Cost per MBTU $ 12.75 /MBTU
      (3) Annual Dollar Decrease/Increase ((1)x(2)) $ 5[illegible] /Yr.
      (4) Differential Escalation Rate (_%) Factor 12.[illegible]
      (5) Discounted Dollar Decrease/Increase (3)x(4) $ [illegible]
   b. Type of Fuel: Electricity
      (1) Annual Energy Decrease (+)/Increase (-) [illegible] MBTU
      (2) Cost per MBTU $ [illegible] /MBTU
      (3) Annual Dollar Decrease/Increase ((1)X(2)) $ [illegible] /Yr.
      (4) Differential Escalation Rate (7 %) Factor 12.[illegible]
      (5) Discounted Dollar Decrease/Increase ((3)x(4)) $ [illegible]
   c. Type of Fuel:
      (1) Annual Energy Decrease (+)/Increase (-) ______ MBTU
      (2) Cost per MBTU $ ______ /MBTU
      (3) Annual Dollar Decrease/Increase ((1)x(2)) $ ______ /Yr.
      (4) Differential Escalation Rate (_%) Factor ______
      (5) Discounted Dollar Decrease/Increase ((3)x(4)) $ ______
   d. Type of Fuel:
      (1) Annual Energy Decrease (+)/Increase (-) ______ MBTU
      (2) Cost per MBTU $ ______ /MBTU
      (3) Annual Dollar Decrease/Increase ((1)x(2)) $ ______ /Yr.
      (4) Differential Escalation Rate (_%) Factor ______
      (5) Discounted Dollar Decrease/Increase ((3)x(4)) $ ______
   e. Discounted Energy Benefits (3a(5)+3b(5)+3c(5)+3d(5)) $ 719,542
4. Total Benefits (Sum 2f+3e) $ 664,209
5. Discounted Benefit/Cost Ratio (Line 4÷Line 1d) 1.854
6. Total Annual Energy Savings (3a(1)+3b(1)+3c(1)+3d(1)) 4,750
7. E/C Ratio (Line 6 ÷ Line 1a/1000) 15.0
8. Annual $ Savings (2d+3a(3)+3b(3)+3c(3)+3d(3)) $ 48,132
9. Pay-back Period ((Line 1a - Salvage)÷Line 8) 6.58
10. Life-Cycle Cost (Line 1d - 2f - 3e) $ - 305,926

FORM A-1

ECIP ECONOMIC ANALYSIS SUMMARY

Location: [illegible] FY 84
Project: Field House
Add Roof Insulation
Economic Life: 25 Yrs. Date Prepared [illegible] Prepared by [illegible]

COSTS
1. Non-recurring Initial Capital Costs:
   a. CWE $ 115,8[illegible]
   b. Design $ 15,215
   c. Salvage $ 0
   d. Total $ 131,015

BENEFITS
2. Recurring Benefit/Cost Differential Other Than Energy:
   a. Annual Labor Decrease (+)/Increase (-) $ -2,536 /Yr.
   b. Annual Material Decrease (+)/Increase (-) $ 0 /Yr.
   c. Other Annual Decrease (+)/Increase (-) $ 0 /Yr.
   d. Total Costs $ -2,536 /Yr.
   e. 10% Discount Factor $ 9.524
   f. Discounted Recurring Cost (d x e) $ -24,153
3. Recurring Energy Benefit/Costs:
   a. Type of Fuel: Fuel Oil
      (1) Annual Energy Decrease (+)/Increase (-) 1,476 MBTU
      (2) Cost per MBTU $ 13.75 /MBTU
      (3) Annual Dollar Decrease/Increase ((1)x(2)) $ 20,[illegible] /Yr.
      (4) Differential Escalation Rate (8 %) Factor [illegible].050
      (5) Discounted Dollar Decrease/Increase (3)x(4) $ 4[illegible],7[illegible]
   b. Type of Fuel: Electricity
      (1) Annual Energy Decrease (+)/Increase (-) 261 MBTU
      (2) Cost per MBTU $ 2.07 /MBTU
      (3) Annual Dollar Decrease/Increase ((1)X(2)) $ 541 /Yr.
      (4) Differential Escalation Rate (7 %) Factor 16.[illegible]49
      (5) Discounted Dollar Decrease/Increase ((3)x(4)) $ 14,45[illegible]
   c. Type of Fuel:
      (1) Annual Energy Decrease (+)/Increase (-) MBTU
      (2) Cost per MBTU $ /MBTU
      (3) Annual Dollar Decrease/Increase ((1)x(2)) $ /Yr.
      (4) Differential Escalation Rate (__%) Factor
      (5) Discounted Dollar Decrease/Increase ((3)x(4)) $
   d. Type of Fuel:
      (1) Annual Energy Decrease (+)/Increase (-) MBTU
      (2) Cost per MBTU $ /MBTU
      (3) Annual Dollar Decrease/Increase ((1)x(2)) $ /Yr.
      (4) Differential Escalation Rate (__%) Factor
      (5) Discounted Dollar Decrease/Increase ((3)x(4)) $
   e. Discounted Energy Benefits (3a(5)+3b(5)+3c(5)+3d(5)) $ 422,254
4. Total Benefits (Sum 2f+3e) $ 398,101
5. Discounted Benefit/Cost Ratio (Line 4 ÷ Line 1d) 3.039
6. Total Annual Energy Savings (3a(1)+3b(1)+3c(1)+3d(1)) 1,737
7. E/C Ratio (Line 6 ÷ Line 1a/1000) 15.0
8. Annual $ Savings (2d+3a(3)+3b(3)+3c(3)+3d(3)) $ 18,604
9. Pay-back Period ((Line 1a - Salvage) ÷ Line 8) 6.22
10. Life-Cycle Cost (Line 1d - 2f - 3e) $ -267,086

FORM A-1

ECIP ECONOMIC ANALYSIS SUMMARY

Location: Colorado Springs, CO FY 84
Project: Field House
2 and 3
Economic Life: 25 Yrs. Date Prepared 9/82 Prepared by JLP

COSTS
1. Non-recurring Initial Capital Costs:
   a. CWE $ 890,700
   b. Design $ 116,461
   c. Salvage $ 0
   d. Total $1,007,161

BENEFITS
2. Recurring Benefit/Cost Differential Other Than Energy:
   a. Annual Labor Decrease (+)/Increase (-) $ -19,495/Yr.
   b. Annual Material Decrease (+)/Increase (-) $ 0 /Yr.
   c. Other Annual Decrease (+)/Increase (-) $ 0 /Yr.
   d. Total Costs $ -19,495 /Yr.
   e. 10% Discount Factor $ 9.524
   f. Discounted Recurring Cost (d x e) $ -185,655
3. Recurring Energy Benefit/Costs:
   a. Type of Fuel: Fuel Oil
      (1) Annual Energy Decrease (+)/Increase (-) 12,794 MBTU
      (2) Cost per MBTU $ 13.79 /MBTU
      (3) Annual Dollar Decrease/Increase ((1)x(2)) $ 176,164 /Yr.
      (4) Differential Escalation Rate (5 %) Factor 20.050
      (5) Discounted Dollar Decrease/Increase (3)x(4) $ 3,532,088
   b. Type of Fuel: Electricity
      (1) Annual Energy Decrease (+)/Increase (-) 569 MBTU
      (2) Cost per MBTU $ [illegible] /MBTU
      (3) Annual Dollar Decrease/Increase ((1)X(2)) $ [illegible] /Yr.
      (4) Differential Escalation Rate (7 %) Factor 16.[illegible]49
      (5) Discounted Dollar Decrease/Increase ((3)x(4)) $ 31,532
   c. Type of Fuel: _____
      (1) Annual Energy Decrease (+)/Increase (-) _____ MBTU
      (2) Cost per MBTU $ _____ /MBTU
      (3) Annual Dollar Decrease/Increase ((1)x(2)) $ _____ /Yr.
      (4) Differential Escalation Rate (_ %) Factor _____
      (5) Discounted Dollar Decrease/Increase ((3)x(4)) $ _____
   d. Type of Fuel: _____
      (1) Annual Energy Decrease (+)/Increase (-) _____ MBTU
      (2) Cost per MBTU $ _____ /MBTU
      (3) Annual Dollar Decrease/Increase ((1)x(2)) $ _____ /Yr.
      (4) Differential Escalation Rate (_ %) Factor _____
      (5) Discounted Dollar Decrease/Increase ((3)x(4)) $ _____
   e. Discounted Energy Benefits (3a(5)+3b(5)+3c(5)+3d(5)) $3,563,620
4. Total Benefits (Sum 2f+3e) $3,377,965
5. Discounted Benefit/Cost Ratio (Line 4÷Line 1d) 3.354
6. Total Annual Energy Savings (3a(1)+3b(1)+3c(1)+3d(1)) 13,363
7. E/C Ratio (Line 6 ÷ Line 1a/1000) 15.0
8. Annual $ Savings (2d+3a(3)+3b(3)+3c(3)+3d(3)) $158,418
9. Pay-back Period ((Line 1a - Salvage)÷Line 8) 5.62
10. Life-Cycle Cost (Line 1d - 2f - 3e) $ -2,370,804

FORM A-1

ECIP ECONOMIC ANALYSIS SUMMARY

Location: Colorado Springs, CO FY 84
Project: Field House
2, 3 and 4
Economic Life: 25 Yrs. Date Prepared 9/82 Prepared by JLD

COSTS

1. Non-recurring Initial Capital Costs:
   a. CWE $ 991,266
   b. Design $ 130,239
   c. Salvage $ 0
   d. Total $ 1,121,506

BENEFITS

2. Recurring Benefit/Cost Differential Other Than Energy:
   a. Annual Labor Decrease (+)/Increase (-) $ -21,707 /Yr.
   b. Annual Material Decrease (+)/Increase (-) $ 0 /Yr.
   c. Other Annual Decrease (+)/Increase (-) $ 0 /Yr.
   d. Total Costs $ -21,707 /Yr.
   e. 10% Discount Factor $ 9.524
   f. Discounted Recurring Cost (d x e) $ -206,737
3. Recurring Energy Benefit/Costs:
   a. Type of Fuel: Fuel Oil
      (1) Annual Energy Decrease (+)/Increase (-) 14,550 MBTU
      (2) Cost per MBTU $ 13.75 /MBTU
      (3) Annual Dollar Decrease/Increase ((1)x(2)) $ 193,609 /Yr.
      (4) Differential Escalation Rate (6 %) Factor 6.050
      (5) Discounted Dollar Decrease/Increase (3)x(4) $ [illegible]
   b. Type of Fuel: Electricity
      (1) Annual Energy Decrease (+)/Increase (-) 919 MBTU
      (2) Cost per MBTU $ 2.67 /MBTU
      (3) Annual Dollar Decrease/Increase ((1)x(2)) $ 2,514 /Yr.
      (4) Differential Escalation Rate (7 %) Factor 16.149
      (5) Discounted Dollar Decrease/Increase ((3)x(4)) $ 45,375
   c. Type of Fuel: ______
      (1) Annual Energy Decrease (+)/Increase (-) ______ MBTU
      (2) Cost per MBTU $ ______ /MBTU
      (3) Annual Dollar Decrease/Increase ((1)x(2)) $ ______ /Yr.
      (4) Differential Escalation Rate (__%) Factor ______
      (5) Discounted Dollar Decrease/Increase ((3)x(4)) $ ______
   d. Type of Fuel: ______
      (1) Annual Energy Decrease (+)/Increase (-) ______ MBTU
      (2) Cost per MBTU $ ______ /MBTU
      (3) Annual Dollar Decrease/Increase ((1)x(2)) $ ______ /Yr.
      (4) Differential Escalation Rate (__%) Factor ______
      (5) Discounted Dollar Decrease/Increase ((3)x(4)) $ ______
   e. Discounted Energy Benefits (3a(5)+3b(5)+3c(5)+3d(5)) $ 3,927,235
4. Total Benefits (Sum 2f+3e) $ 3,720,498
5. Discounted Benefit/Cost Ratio (Line 4÷Line 1d) 3.31
6. Total Annual Energy Savings (3a(1)+3b(1)+3c(1)+3d(1)) 14,569
7. E/C Ratio (Line 6 ÷ Line 1a/1000) 15.0
8. Annual $ Savings (2d+3a(3)+3b(3)+3c(3)+3d(3)) $ 174,416
9. Pay-back Period ((Line 1a - Salvage)÷Line 8) 5.68
10. Life-Cycle Cost (Line 1d 2f - 3e) [illegible] - 2,598,992

FORM A-1

ECIP ECONOMIC ANALYSIS SUMMARY

Location: Colorado Springs CO   FY 84
Project: Field House
Solar Domestic Hot Water System - Conoflt[illegible]
Economic Life: 25 Yrs.   Date Prepared 9/82   Prepared by [illegible]

COSTS

1. Non-recurring Initial Capital Costs:
   a. CWE $ 18,067
   b. Design $ 2,374
   c. Salvage $ 0
   d. Total $ 20,441

BENEFITS

2. Recurring Benefit/Cost Differential Other Than Energy:
   a. Annual Labor Decrease (+)/Increase (-) $ -396 /Yr.
   b. Annual Material Decrease (+)/Increase (-) $ 0 /Yr.
   c. Other Annual Decrease (+)/Increase (-) $ 0 /Yr.
   d. Total Costs $ -396 /Yr.
   e. 10% Discount Factor $ 9.524
   f. Discounted Recurring Cost (d x e) $ -3,772
3. Recurring Energy Benefit/Costs:
   a. Type of Fuel: Fuel Oil
      (1) Annual Energy Decrease (+)/Increase(-)   571 MBTU
      (2) Cost per MBTU $ [illegible] /MBTU
      (3) Annual Dollar Decrease/Increase ((1)x(2)) $ 7,965 /Yr.
      (4) Differential Escalation Rate (5 %)Factor   [illegible]
      (5) Discounted Dollar Decrease/Increase(3)x(4) $ 157,753
   b. Type of Fuel: Electricity
      (1) Annual Energy Decrease (+)/Increase (-)   -300 MBTU
      (2) Cost per MBTU $ [illegible] /MBTU
      (3) Annual Dollar Decrease/Increase ((1)X(2)) $ -421 /Yr.
      (4) Differential Escalation Rate (7 %) Factor   [illegible]
      (5) Discounted Dollar Decrease/Increase ((3)x(4)) $ -16,623
   c. Type of Fuel: ____
      (1) Annual Energy Decrease (+)/Increase (-)   MBTU
      (2) Cost per MBTU $ /MBTU
      (3) Annual Dollar Decrease/Increase ((1)x(2)) $ /Yr.
      (4) Differential Escalation Rate (__%) Factor
      (5) Discounted Dollar Decrease/Increase ((3)x(4)) $
   d. Type of Fuel: ____
      (1) Annual Energy Decrease (+)/Increase (-)   MBTU
      (2) Cost per MBTU $ /MBTU
      (3) Annual Dollar Decrease/Increase ((1)x(2)) $ /Yr.
      (4) Differential Escalation Rate (__%)Factor
      (5) Discounted Dollar Decrease/Increase ((3)x(4)) $
   e. Discounted Energy Benefits (3a(5)+3b(5)+3c(5)+3d(5)) $ 141,130
4. Total Benefits (Sum 2f+3e) $ 137,359
5. Discounted Benefit/Cost Ratio (Line 4÷Line 1d)   6.720
6. Total Annual Energy Savings (3a(1)+3b(1)+3c(1)+3d(1))   271
7. E/C Ratio (Line 6 ÷ Line 1a/1000)   15.0
8. Annual $ Savings (2d+3a(3)+3b(3)+3c(3)+3d(3)) $ 6,551
9. Pay-back Period ((Line 1a - Salvage)÷Line 8)   2.76
10. Life-Cycle Cost (Line 1d - 2f - 3e) $ - 116,917

FORM A-1

ECIP ECONOMIC ANALYSIS SUMMARY

Location: Colorado Springs, CO FY 84
Project: Aero Lab
Seasonal Heating and Cooling
Economic Life: 5 Yrs. Date Prepared 11/82 Prepared by JLP

COSTS

1. Non-recurring Initial Capital Costs:
   a. CWE $ 20,133
   b. Design $ 2,645
   c. Salvage $ 0
   d. Total $ 22,778

BENEFITS

2. Recurring Benefit/Cost Differential Other Than Energy:
   a. Annual Labor Decrease (+)/Increase (-) $ -441 /Yr.
   b. Annual Material Decrease (+)/Increase (-) $ 0 /Yr.
   c. Other Annual Decrease (+)/Increase (-) $ 0 /Yr.
   d. Total Costs $ -441 /Yr.
   e. 10% Discount Factor $ 7.986
   f. Discounted Recurring Cost (d x e) $ -2,519
3. Recurring Energy Benefit/Costs:
   a. Type of Fuel: Fuel Oil
      (1) Annual Energy Decrease (+)/Increase (-) 273 MBTU
      (2) Cost per MBTU $ 13.78 /MBTU
      (3) Annual Dollar Decrease/Increase ((1)x(2)) $ 3,762 /Yr.
      (4) Differential Escalation Rate (5 %) Factor [illegible]
      (5) Discounted Dollar Decrease/Increase (3)x(4) $ 47,527
   b. Type of Fuel: Electricity
      (1) Annual Energy Decrease (+)/Increase (-) 29 MBTU
      (2) Cost per MBTU $ 3.07 /MBTU
      (3) Annual Dollar Decrease/Increase ((1)X(2)) $ 89 /Yr.
      (4) Differential Escalation Rate (7 %) Factor 12.278
      (5) Discounted Dollar Decrease/Increase ((3)x(4)) $ 1,093
   c. Type of Fuel: ____
      (1) Annual Energy Decrease (+)/Increase (-) ____ MBTU
      (2) Cost per MBTU $ ____ /MBTU
      (3) Annual Dollar Decrease/Increase ((1)x(2)) $ ____ /Yr.
      (4) Differential Escalation Rate (__%) Factor ____
      (5) Discounted Dollar Decrease/Increase ((3)x(4)) $ ____
   d. Type of Fuel: ____
      (1) Annual Energy Decrease (+)/Increase (-) ____ MBTU
      (2) Cost per MBTU $ ____ /MBTU
      (3) Annual Dollar Decrease/Increase ((1)x(2)) $ ____ /Yr.
      (4) Differential Escalation Rate (__%) Factor ____
      (5) Discounted Dollar Decrease/Increase ((3)x(4)) $ ____
   e. Discounted Energy Benefits (3a(5)+3b(5)+3c(5)+3d(5)) $ 50,420
4. Total Benefits (Sum 2f+3e) $ 46,901
5. Discounted Benefit/Cost Ratio (Line 4÷Line 1d) 2.059
6. Total Annual Energy Savings (3a(1)+3b(1)+3c(1)+3d(1)) 302
7. E/C Ratio (Line 6 ÷ Line 1a/1000) 15.0
8. Annual $ Savings (2d+3a(3)+3b(3)+3c(3)+3d(3)) $ 3,410
9. Pay-back Period ((Line 1a - Salvage)÷Line 8) 5.90 yr
10. Life Cycle Cost (Line 1d - 2f - 3e) -$ 24,123

FORM A-1

ECIP ECONOMIC ANALYSIS SUMMARY

Location: Colorado Springs, Co FY 84
Project: Aero Lab
Night Setback in Lobbies
Economic Life: 15 Yrs. Date Prepared 10/82 Prepared by JLP

COSTS
1. Non-recurring Initial Capital Costs:
   a. CWE $ 3,266
   b. Design $ 429
   c. Salvage $ —
   d. Total $ 3695

BENEFITS
2. Recurring Benefit/Cost Differential Other Than Energy:
   a. Annual Labor Decrease (+)/Increase (-) $ -72 /Yr.
   b. Annual Material Decrease (+)/Increase (-) $ 0 /Yr.
   c. Other Annual Decrease (+)/Increase (-) $ 0 /Yr.
   d. Total Costs $ -72 /Yr.
   e. 10% Discount Factor $ 7.980
   f. Discounted Recurring Cost (d x e) $ -575
3. Recurring Energy Benefit/Costs:
   a. Type of Fuel: Fuel Oil
      (1) Annual Energy Decrease (+)/Increase(-) 60 MBTU
      (2) Cost per MBTU $ 12.75 /MBTU
      (3) Annual Dollar Decrease/Increase ((1)x(2)) $ 827 /Yr.
      (4) Differential Escalation Rate (5 %)Factor 13.112
      (5) Discounted Dollar Decrease/Increase(3)x(4) $ 10,944
   b. Type of Fuel: Electricity
      (1) Annual Energy Decrease (+)/Increase (-) -11 MBTU
      (2) Cost per MBTU $ 3.07 /MBTU
      (3) Annual Dollar Decrease/Increase ((1)X(2)) $ -34 /Yr.
      (4) Differential Escalation Rate (7 %) Factor 12.275
      (5) Discounted Dollar Decrease/Increase ((3)x(4)) $ -417
   c. Type of Fuel:
      (1) Annual Energy Decrease (+)/Increase (-) MBTU
      (2) Cost per MBTU $ /MBTU
      (3) Annual Dollar Decrease/Increase ((1)x(2)) $ /Yr.
      (4) Differential Escalation Rate (%) Factor
      (5) Discounted Dollar Decrease/Increase ((3)x(4)) $
   d. Type of Fuel:
      (1) Annual Energy Decrease (+)/Increase (-) MBTU
      (2) Cost per MBTU $ /MBTU
      (3) Annual Dollar Decrease/Increase ((1)x(2)) $ /Yr.
      (4) Differential Escalation Rate (%)Factor
      (5) Discounted Dollar Decrease/Increase ((3)x(4)) $
   e. Discounted Energy Benefits (3a(5)+3b(5)+3c(5)+3d(5)) $ 10,427
4. Total Benefits (Sum 2f+3e) $ 9,852
5. Discounted Benefit/Cost Ratio (Line 4÷Line 1d) 2.66
6. Total Annual Energy Savings (3a(1)+3b(1)+3c(1)+3d(1)) 49 MBtu
7. E/C Ratio (Line 6 ÷ Line 1a/1000) 15.0
8. Annual $ Savings (2d+3a(3)+3b(3)+3c(3)+3d(3)) $ 721
9. Pay-back Period ((Line 1a - Salvage)÷Line 8) 4.53
10. Life Cycle Cost (Line 1d-2f-3e) -$ 6,157

FORM A-1

ECIP ECONOMIC ANALYSIS SUMMARY

Location: Colorado Springs, CO FY 84
Project: [illegible]
Demand Controls
Economic Life: 15 Yrs. Date Prepared 10/82 Prepared by [illegible]

COSTS

1. Non-recurring Initial Capital Costs:
   a. CWE $ [illegible]
   b. Design $ 3434
   c. Salvage $ 0
   d. Total $ [illegible]

BENEFITS

2. Recurring Benefit/Cost Differential Other Than Energy:
   a. Annual Labor Decrease (+)/Increase (-) $ -573 /Yr.
   b. Annual Material Decrease (+)/Increase (-) $ 0 /Yr.
   c. Other Annual Decrease (+)/Increase (-) $ 0 /Yr.
   d. Total Costs $ -572 /Yr.
   e. 10% Discount Factor $ 7.980
   f. Discounted Recurring Cost (d x e) $ -4,565
3. Recurring Energy Benefit/Costs:
   a. Type of Fuel: Fuel oil
      (1) Annual Energy Decrease (+)/Increase (-) 396 MBTU
      (2) Cost per MBTU $ 13.75 /MBTU
      (3) Annual Dollar Decrease/Increase ((1)x(2)) $ 5,457 /Yr.
      (4) Differential Escalation Rate (8 %) Factor 13.112
      (5) Discounted Dollar Decrease/Increase (3)x(4) $ 71,552
   b. Type of Fuel: Electricity
      (1) Annual Energy Decrease (+)/Increase (-) -4 MBTU
      (2) Cost per MBTU $ 3.07 /MBTU
      (3) Annual Dollar Decrease/Increase ((1)X(2)) $ -12 /Yr.
      (4) Differential Escalation Rate (7 %) Factor 2.275
      (5) Discounted Dollar Decrease/Increase ((3)x(4)) $ -147
   c. Type of Fuel:
      (1) Annual Energy Decrease (+)/Increase (-) MBTU
      (2) Cost per MBTU $ /MBTU
      (3) Annual Dollar Decrease/Increase ((1)x(2)) $ /Yr.
      (4) Differential Escalation Rate (_%) Factor
      (5) Discounted Dollar Decrease/Increase ((3)x(4)) $
   d. Type of Fuel:
      (1) Annual Energy Decrease (+)/Increase (-) MBTU
      (2) Cost per MBTU $ /MBTU
      (3) Annual Dollar Decrease/Increase ((1)x(2)) $ /Yr.
      (4) Differential Escalation Rate (_%) Factor
      (5) Discounted Dollar Decrease/Increase ((3)x(4)) $
   e. Discounted Energy Benefits (3a(5)+3b(5)+3c(5)+3d(5)) $ 71,405
4. Total Benefits (Sum 2f+3e) $ 66,840
5. Discounted Benefit/Cost Ratio (Line 4÷Line 1d) 2.261
6. Total Annual Energy Savings (3a(1)+3b(1)+3c(1)+3d(1)) 392
7. E/C Ratio (Line 6 ÷ Line 1a/1000) 15.2
8. Annual $ Savings (2d+3a(3)+3b(3)+3c(3)+3d(3)) $ 4,873
9. Pay-back Period ((Line 1a - Salvage)÷Line 8) 5.36
10. Life Cycle Cost (Line 1d - 2f - 3e) - $ 37,273

FORM A-1

ECIP ECONOMIC ANALYSIS SUMMARY

Location: Colorado Springs, CO FY 84
Project: Aero Lab
Evaporative Cooling
Economic Life: 25 Yrs. Date Prepared 10/82 Prepared by JLD

COSTS

1. Non-recurring Initial Capital Costs:
   - a. CWE $ [illegible]
   - b. Design $
   - c. Salvage $ [illegible]
   - d. Total $

BENEFITS

2. Recurring Benefit/Cost Differential Other Than Energy:
   - a. Annual Labor Decrease (+)/Increase (-) $ /Yr.
   - b. Annual Material Decrease (+)/Increase (-) $ /Yr.
   - c. Other Annual Decrease (+)/Increase (-) $ /Yr.
   - d. Total Costs $ /Yr.
   - e. 10% Discount Factor $ [illegible]
   - f. Discounted Recurring Cost (d x e) $
3. Recurring Energy Benefit/Costs:
   - a. Type of Fuel: Fuel Oil
     - (1) Annual Energy Decrease (+)/Increase(-) -202 MBTU
     - (2) Cost per MBTU $ [illegible] /MBTU
     - (3) Annual Dollar Decrease/Increase ((1)x(2)) $ /Yr.
     - (4) Differential Escalation Rate (6 %)Factor 26.050
     - (5) Discounted Dollar Decrease/Increase(3)x(4) $
   - b. Type of Fuel: Electricity
     - (1) Annual Energy Decrease (+)/Increase (-) 32 MBTU
     - (2) Cost per MBTU $ 5.07 /MBTU
     - (3) Annual Dollar Decrease/Increase ((1)X(2)) $ /Yr.
     - (4) Differential Escalation Rate (7 %) Factor 16.19
     - (5) Discounted Dollar Decrease/Increase ((3)x(4)) $
   - c. Type of Fuel:
     - (1) Annual Energy Decrease (+)/Increase (-) MBTU
     - (2) Cost per MBTU $ /MBTU
     - (3) Annual Dollar Decrease/Increase ((1)x(2)) $ /Yr.
     - (4) Differential Escalation Rate (__%) Factor
     - (5) Discounted Dollar Decrease/Increase ((3)x(4)) $
   - d. Type of Fuel:
     - (1) Annual Energy Decrease (+)/Increase (-) MBTU
     - (2) Cost per MBTU $ /MBTU
     - (3) Annual Dollar Decrease/Increase ((1)x(2)) $ /Yr.
     - (4) Differential Escalation Rate (__%)Factor
     - (5) Discounted Dollar Decrease/Increase ((3)x(4)) $
   - e. Discounted Energy Benefits (3a(5)+3b(5)+3c(5)+3d(5)) $
4. Total Benefits (Sum 2f+3e) $
5. Discounted Benefit/Cost Ratio (Line 4÷Line 1d)
6. Total Annual Energy Savings (3a(1)+3b(1)+3c(1)+3d(1)) -170
7. E/C Ratio (Line 6 ÷ Line 1a/1000)
8. Annual $ Savings (2d+3a(3)+3b(3)+3c(3)+3d(3)) $
9. Pay-back Period ((Line 1a - Salvage)÷Line 8)

10. Life Cycle Cost (Line 1d - 2f - 3e) -$

FORM A-1

ECIP ECONOMIC ANALYSIS SUMMARY

Location: [illegible] FY [illegible]

Project: [illegible]

[illegible]

Economic Life: [illegible] Yrs. Date Prepared [illegible] Prepared by [illegible]

COSTS

1. Non-recurring Initial Capital Costs:
   a. C&E $ [illegible]
   b. Design $ [illegible]
   c. [illegible] $ [illegible]
   d. Total $ [illegible]

BENEFITS

2. Recurring Benefit/Cost Differential Other Than Energy:
   a. Annual Labor Decrease (+)/Increase (-) $ [illegible] /Yr.
   b. Annual Material Decrease (+)/Increase (-) $ [illegible] /Yr.
   c. Other Annual Decrease (+)/Increase (-) $ [illegible] /Yr.
   d. Total Costs $ [illegible] /Yr.
   e. 10% Discount Factor $ [illegible]
   f. Discounted Recurring Cost (d x e) $ [illegible]
3. Recurring Energy Benefit/Costs:
   a. Type of Fuel: [illegible]
      (1) Annual Energy Decrease (+)/Increase(-) [illegible] MBTU
      (2) Cost per MBTU $ [illegible] /MBTU
      (3) Annual Dollar Decrease/Increase ((1)x(2)) $ [illegible] /Yr.
      (4) Differential Escalation Rate ([illegible] %)Factor [illegible]
      (5) Discounted Dollar Decrease/Increase(3)x(4) $ [illegible]
   b. Type of Fuel: Electricity
      (1) Annual Energy Decrease (+)/Increase (-) [illegible] MBTU
      (2) Cost per MBTU $ [illegible] /MBTU
      (3) Annual Dollar Decrease/Increase ((1)X(2)) $ 60 /Yr.
      (4) Differential Escalation Rate ([illegible] %) Factor [illegible]
      (5) Discounted Dollar Decrease/Increase ((3)x(4)) $ [illegible]
   c. Type of Fuel:
      (1) Annual Energy Decrease (+)/Increase (-) MBTU
      (2) Cost per MBTU $ /MBTU
      (3) Annual Dollar Decrease/Increase ((1)x(2)) $ /Yr.
      (4) Differential Escalation Rate (__%) Factor
      (5) Discounted Dollar Decrease/Increase ((3)x(4)) $
   d. Type of Fuel:
      (1) Annual Energy Decrease (+)/Increase (-) MBTU
      (2) Cost per MBTU $ /MBTU
      (3) Annual Dollar Decrease/Increase ((1)x(2)) $ /Yr.
      (4) Differential Escalation Rate (__%)Factor
      (5) Discounted Dollar Decrease/Increase ((3)x(4)) $
   e. Discounted Energy Benefits (3a(5)+3b(5)+3c(5)+3d(5)) $ [illegible]
4. Total Benefits (Sum 2f+3e) $ [illegible]
5. Discounted Benefit/Cost Ratio (Line 4÷Line 1d) [illegible]
6. Total Annual Energy Savings (3a(1)+3b(1)+3c(1)+3d(1)) [illegible] mbtu
7. E/C Ratio (Line 6 ÷ Line 1a/1000) 15.0
8. Annual $ Savings (2d+3a(3)+3b(3)+3c(3)+3d(3)) $ [illegible]
9. Pay-back Period ((Line 1a - Salvage)÷Line 8) 5.60
10. Life Cycle Cost (Line 1d - 2f - 3e) — $ [illegible]

FORM A-1

ECIP ECONOMIC ANALYSIS SUMMARY

Location: [illegible] FY [illegible]
Project: [illegible]
[illegible]
Economic Life: 25 Yrs. Date Prepared [illegible] Prepared by [illegible]

COSTS

1. Non-recurring Initial Capital Costs:
   a. CWE $ [illegible]
   b. Design $ [illegible]
   c. Salvage $ 0
   d. Total $ [illegible]

BENEFITS

2. Recurring Benefit/Cost Differential Other Than Energy:
   a. Annual Labor Decrease (+)/Increase (-) $ -1,[illegible] /Yr.
   b. Annual Material Decrease (+)/Increase (-) $ 0 /Yr.
   c. Other Annual Decrease (+)/Increase (-) $ 0 /Yr.
   d. Total Costs $ -1,[illegible] /Yr.
   e. 10% Discount Factor $ 9.524
   f. Discounted Recurring Cost (d x e) $ -1[illegible],[illegible]16
3. Recurring Energy Benefit/Costs:
   a. Type of Fuel: Fuel Oil
      (1) Annual Energy Decrease (+)/Increase(-) [illegible] MBTU
      (2) Cost per MBTU $ [illegible] /MBTU
      (3) Annual Dollar Decrease/Increase ((1)x(2)) $ [illegible] /Yr.
      (4) Differential Escalation Rate ([illegible] %)Factor [illegible]
      (5) Discounted Dollar Decrease/Increase(3)x(4) $ [illegible]
   b. Type of Fuel: Electricity
      (1) Annual Energy Decrease (+)/Increase (-) 147 MBTU
      (2) Cost per MBTU $ [illegible] /MBTU
      (3) Annual Dollar Decrease/Increase ((1)X(2)) $ 4[illegible] /Yr.
      (4) Differential Escalation Rate (7 %) Factor 1[illegible].[illegible]49
      (5) Discounted Dollar Decrease/Increase ((3)x(4)) $ [illegible]
   c. Type of Fuel:
      (1) Annual Energy Decrease (+)/Increase (-) MBTU
      (2) Cost per MBTU $ /MBTU
      (3) Annual Dollar Decrease/Increase ((1)x(2)) $ /Yr.
      (4) Differential Escalation Rate (_%) Factor
      (5) Discounted Dollar Decrease/Increase ((3)x(4)) $
   d. Type of Fuel:
      (1) Annual Energy Decrease (+)/Increase (-) MBTU
      (2) Cost per MBTU $ /MBTU
      (3) Annual Dollar Decrease/Increase ((1)x(2)) $ /Yr.
      (4) Differential Escalation Rate (_%)Factor
      (5) Discounted Dollar Decrease/Increase ((3)x(4)) $
   e. Discounted Energy Benefits (3a(5)+3b(5)+3c(5)+3d(5)) $ [illegible]
4. Total Benefits (Sum 2f+3e) $ [illegible]
5. Discounted Benefit/Cost Ratio (Line 4÷Line 1d) [illegible]
6. Total Annual Energy Savings (3a(1)+3b(1)+3c(1)+3d(1)) [illegible] MBtu
7. E/C Ratio (Line 6 ÷ Line 1a/1000) 15.0[illegible]
8. Annual $ Savings (2d+3a(3)+3b(3)+3c(3)+3d(3)) $ [illegible]
9. Pay-back Period ((Line 1a - Salvage)÷Line 8) 5.[illegible]7
10. Life Cycle Cost (Line 1d - 2f - 3e) - $ [illegible],595

FORM A-1

ECIP ECONOMIC ANALYSIS SUMMARY

Location: [illegible] FY 84
Project: [illegible]
Economic Life: 25 Yrs. Date Prepared [illegible] Prepared by [illegible]

COSTS

1. Non-recurring Initial Capital Costs:
   - a. CWE $ 3,468
   - b. Design $ 521
   - c. Salvage $ [illegible]
   - d. Total $ 4,489

BENEFITS

2. Recurring Benefit/Cost Differential Other Than Energy:
   - a. Annual Labor Decrease (+)/Increase (-) $ -87 /Yr.
   - b. Annual Material Decrease (+)/Increase (-) $ 0 /Yr.
   - c. Other Annual Decrease (+)/Increase (-) $ 0 /Yr.
   - d. Total Costs $ -87 /Yr.
   - e. 10% Discount Factor $ 9.524
   - f. Discounted Recurring Cost (d x e) $ -829
3. Recurring Energy Benefit/Costs:
   - a. Type of Fuel: Fuel Oil
     - (1) Annual Energy Decrease (+)/Increase (-) -84 MBTU
     - (2) Cost per MBTU $ 13.78 /MBTU
     - (3) Annual Dollar Decrease/Increase ((1)x(2)) $ -1,158 /Yr.
     - (4) Differential Escalation Rate (5 %) Factor 20.050
     - (5) Discounted Dollar Decrease/Increase (3)x(4) $ -23,218
   - b. Type of Fuel: Electricity
     - (1) Annual Energy Decrease (+)/Increase (-) 515 MBTU
     - (2) Cost per MBTU $ [illegible] /MBTU
     - (3) Annual Dollar Decrease/Increase ((1)X(2)) $ 1,581 /Yr.
     - (4) Differential Escalation Rate (7 %) Factor 18.041
     - (5) Discounted Dollar Decrease/Increase ((3)x(4)) $ 28,536
   - c. Type of Fuel:
     - (1) Annual Energy Decrease (+)/Increase (-) MBTU
     - (2) Cost per MBTU $ /MBTU
     - (3) Annual Dollar Decrease/Increase ((1)x(2)) $ /Yr.
     - (4) Differential Escalation Rate (_ %) Factor
     - (5) Discounted Dollar Decrease/Increase ((3)x(4)) $
   - d. Type of Fuel:
     - (1) Annual Energy Decrease (+)/Increase (-) MBTU
     - (2) Cost per MBTU $ /MBTU
     - (3) Annual Dollar Decrease/Increase ((1)x(2)) $ /Yr.
     - (4) Differential Escalation Rate (_ %) Factor
     - (5) Discounted Dollar Decrease/Increase ((3)x(4)) $
   - e. Discounted Energy Benefits (3a(5)+3b(5)+3c(5)+3d(5)) $ 5,318
4. Total Benefits (Sum 2f+3e) $ 4,489
5. Discounted Benefit/Cost Ratio (Line 4÷Line 1d) 1.0
6. Total Annual Energy Savings (3a(1)+3b(1)+3c(1)+3d(1)) 431 MBtu
7. E/C Ratio (Line 6 ÷ Line 1a/1000) 124
8. Annual $ Savings (2d+3a(3)+3b(3)+3c(3)+3d(3)) $ 336
9. Pay-back Period ((Line 1a - Salvage)÷Line 8) 11.8 yrs
10. Life-Cycle Cost (1d - 2f - 3e) -$ 0

FORM A-1

ECIP ECONOMIC ANALYSIS SUMMARY

Location: Colorado Springs, Co FY 84
Project: Acc. Lab Trombe Wall
Economic Life: 25 Yrs. Date Prepared 11/83 Prepared by TJD

COSTS

1. Non-recurring Initial Capital Costs:
   a. CWE $ 16,667
   b. Design $ 2,190
   c. Salvage $ 0
   d. Total $ 18,857

BENEFITS

2. Recurring Benefit/Cost Differential Other Than Energy:
   a. Annual Labor Decrease (+)/Increase (-) $ -365 /Yr.
   b. Annual Material Decrease (+)/Increase (-) $ 0 /Yr.
   c. Other Annual Decrease (+)/Increase (-) $ 0 /Yr.
   d. Total Costs $ -365 /Yr.
   e. 10% Discount Factor $ 9.524
   f. Discounted Recurring Cost (d x e) $ -3,476
3. Recurring Energy Benefit/Costs:
   a. Type of Fuel: Fuel Oil
      (1) Annual Energy Decrease (+)/Increase(-) 196 MBTU
      (2) Cost per MBTU $ 13.78 /MBTU
      (3) Annual Dollar Decrease/Increase ((1)x(2)) $ 2,701 /Yr.
      (4) Differential Escalation Rate (5 %) Factor 20.58
      (5) Discounted Dollar Decrease/Increase (3)x(4) $ 54,155
   b. Type of Fuel: Electricity
      (1) Annual Energy Decrease (+)/Increase (-) 54 MBTU
      (2) Cost per MBTU $ 3.07 /MBTU
      (3) Annual Dollar Decrease/Increase ((1)x(2)) $ 166 /Yr.
      (4) Differential Escalation Rate (7 %) Factor 18.049
      (5) Discounted Dollar Decrease/Increase ((3)x(4)) $ 2,996
   c. Type of Fuel: ______
      (1) Annual Energy Decrease (+)/Increase (-) ______ MBTU
      (2) Cost per MBTU $ ______ /MBTU
      (3) Annual Dollar Decrease/Increase ((1)x(2)) $ ______ /Yr.
      (4) Differential Escalation Rate (__%) Factor ______
      (5) Discounted Dollar Decrease/Increase ((3)x(4)) $ ______
   d. Type of Fuel: ______
      (1) Annual Energy Decrease (+)/Increase (-) ______ MBTU
      (2) Cost per MBTU $ ______ /MBTU
      (3) Annual Dollar Decrease/Increase ((1)x(2)) $ ______ /Yr.
      (4) Differential Escalation Rate (__%)Factor ______
      (5) Discounted Dollar Decrease/Increase ((3)x(4)) $ ______
   e. Discounted Energy Benefits (3a(5)+3b(5)+3c(5)+3d(5)) $ 57,151
4. Total Benefits (Sum 2f+3e) $ 53,675
5. Discounted Benefit/Cost Ratio (Line 4÷Line 1d) 2.846
6. Total Annual Energy Savings (3a(1)+3b(1)+3c(1)+3d(1)) 250 MBtu
7. E/C Ratio (Line 6 ÷ Line 1a/1000) 15.0
8. Annual $ Savings (2d+3a(3) 3b(3)+3c(3)+3d(3)) $ 2,502
9. Pay-back Period ((Line 1a - Salvage)÷Line 8) 6.66 yrs
10 Life-Cycle Cost (1d - 2f - 3e) $ -34,818

FORM A-1

ECIP ECONOMIC ANALYSIS SUMMARY

Location: Colorado Springs, CO FY 84

Project: Aero Lab

Sunspace for Test Cell Classroom

Economic Life: 25 Yrs. Date Prepared 1/83 Prepared by JLD

COSTS

1. Non-recurring Initial Capital Costs:
   a. CWE $ 3333
   b. Design $ 438
   c. Salvage $ 0
   d. Total $ [illegible]

BENEFITS

2. Recurring Benefit/Cost Differential Other Than Energy:
   a. Annual Labor Decrease (+)/Increase (-) $ -73 /Yr.
   b. Annual Material Decrease (+)/Increase (-) $ 0 /Yr.
   c. Other Annual Decrease (+)/Increase (-) $ 0 /Yr.
   d. Total Costs $ -73 /Yr.
   e. 10% Discount Factor $ 9.524
   f. Discounted Recurring Cost (d x e) $ -695
3. Recurring Energy Benefit/Costs:
   a. Type of Fuel: Fuel Oil
      (1) Annual Energy Decrease (+)/Increase (-) 46 MBTU
      (2) Cost per MBTU $ 13.78 /MBTU
      (3) Annual Dollar Decrease/Increase ((1)x(2)) $ 634 /Yr.
      (4) Differential Escalation Rate (__%) Factor 20.050
      (5) Discounted Dollar Decrease/Increase (3)x(4) $ 12,712
   b. Type of Fuel:
      (1) Annual Energy Decrease (+)/Increase (-) 4 MBTU
      (2) Cost per MBTU $ 3.07 /MBTU
      (3) Annual Dollar Decrease/Increase ((1)x(2)) $ 12 /Yr.
      (4) Differential Escalation Rate (__%) Factor 18.049
      (5) Discounted Dollar Decrease/Increase ((3)x(4)) $ 217
   c. Type of Fuel:
      (1) Annual Energy Decrease (+)/Increase (-) MBTU
      (2) Cost per MBTU $ /MBTU
      (3) Annual Dollar Decrease/Increase ((1)x(2)) $ /Yr.
      (4) Differential Escalation Rate (__%) Factor
      (5) Discounted Dollar Decrease/Increase ((3)x(4)) $
   d. Type of Fuel:
      (1) Annual Energy Decrease (+)/Increase (-) MBTU
      (2) Cost per MBTU $ /MBTU
      (3) Annual Dollar Decrease/Increase ((1)x(2)) $ /Yr.
      (4) Differential Escalation Rate (__%) Factor
      (5) Discounted Dollar Decrease/Increase ((3)x(4)) $
   e. Discounted Energy Benefits (3a(5)+3b(5)+3c(5)+3d(5)) $ 12,929
4. Total Benefits (Sum 2f+3e) $ 12,234
5. Discounted Benefit/Cost Ratio (Line 4÷Line 1d) 3.244
6. Total Annual Energy Savings (3a(1)+3b(1)+3c(1)+3d(1)) 50 MBtu
7. E/C Ratio (Line 6 ÷ Line 1a/1000) 15.0
8. Annual $ Savings (2d+3a(3)+3b(3)+3c(3)+3d(3)) $ 573
9. Pay-back Period ((Line 1a - Salvage)÷Line 8) 6.207 yrs
10. Life-Cycle Cost (1d - 2f - 3e) -$ 6,463

FORM A-1

ECIP ECONOMIC ANALYSIS SUMMARY

Location: Colorado Springs CO FY 84

Project: [illegible]

Active Solar Heating 6000 ft² 10,800 gal.

Economic Life: 25 Yrs. Date Prepared 1/83 Prepared by [illegible]

COSTS

1. Non-recurring Initial Capital Costs:
   - a. CWE $ 65,265
   - b. Design $ 8,500
   - c. Salvage $ 0
   - d. Total $ 73,766

BENEFITS

2. Recurring Benefit/Cost Differential Other Than Energy:
   - a. Annual Labor Decrease (+)/Increase (-) $ -1,425 /Yr.
   - b. Annual Material Decrease (+)/Increase (-) $ 0 /Yr.
   - c. Other Annual Decrease (+)/Increase (-) $ 0 /Yr.
   - d. Total Costs $ -1,425 /Yr.
   - e. 10% Discount Factor $ [illegible]
   - f. Discounted Recurring Cost (d x e) $ [illegible]
3. Recurring Energy Benefit/Costs:
   - a. Type of Fuel: Fuel Oil
     - (1) Annual Energy Decrease (+)/Increase(-) 1,032 MBTU
     - (2) Cost per MBTU $ 13.79 /MBTU
     - (3) Annual Dollar Decrease/Increase ((1)x(2)) $ 14,231 /Yr.
     - (4) Differential Escalation Rate (_8_%) Factor [illegible]
     - (5) Discounted Dollar Decrease/Increase(3)x(4) $ [illegible]
   - b. Type of Fuel: Electricity
     - (1) Annual Energy Decrease (+)/Increase (-) -54 MBTU
     - (2) Cost per MBTU $ [illegible] /MBTU
     - (3) Annual Dollar Decrease/Increase ((1)X(2)) $ -166 /Yr.
     - (4) Differential Escalation Rate (_7_%) Factor 15.043
     - (5) Discounted Dollar Decrease/Increase ((3)x(4)) $ -2,496
   - c. Type of Fuel: ____
     - (1) Annual Energy Decrease (+)/Increase (-) ____ MBTU
     - (2) Cost per MBTU $ ____ /MBTU
     - (3) Annual Dollar Decrease/Increase ((1)x(2)) $ ____ /Yr.
     - (4) Differential Escalation Rate (_%) Factor ____
     - (5) Discounted Dollar Decrease/Increase ((3)x(4)) $ ____
   - d. Type of Fuel: ____
     - (1) Annual Energy Decrease (+)/Increase (-) ____ MBTU
     - (2) Cost per MBTU $ ____ /MBTU
     - (3) Annual Dollar Decrease/Increase ((1)x(2)) $ ____ /Yr.
     - (4) Differential Escalation Rate (_%)Factor ____
     - (5) Discounted Dollar Decrease/Increase ((3)x(4)) $ ____
   - e. Discounted Energy Benefits (3a(5)+3b(5)+3c(5)+3d(5)) $ 282,135
4. Total Benefits (Sum 2f+3e) $ [illegible] 544
5. Discounted Benefit/Cost Ratio (Line 4÷Line 1d) 3.640
6. Total Annual Energy Savings (3a(1)+3b(1)+3c(1)+3d(1)) 978 MBtu
7. E/C Ratio (Line 6 ÷ Line 1a/1000) 15.0
8. Annual $ Savings (2d+3a(3)+3b(3)+3c(3)+3d(3)) $ 12,639
9. Pay-back Period ((Line 1a - Salvage)÷Line 8) 5.16 yr
10. Life-Cycle Cost (Line 1d - 2f - 3e) -$ 194,778

FORM A-1

ECIP ECONOMIC ANALYSIS SUMMARY

Location: Colorado Springs, CO FY 86

Project: Aero Lab

Solar DHW 120 ft², 215 gal

Economic Life: 25 Yrs. Date Prepared 1/82 Prepared by [illegible]

COSTS

1. Non-recurring Initial Capital Costs:
   a. CWE $ 1,786
   b. Design $ 235
   c. [illegible] $ 0
   d. Total $ 2,021

BENEFITS

2. Recurring Benefit/Cost Differential Other Than Energy:
   a. Annual Labor Decrease (+)/Increase (-) $ -38 /Yr.
   b. Annual Material Decrease (+)/Increase (-) $ 0 /Yr.
   c. Other Annual Decrease (+)/Increase (-) $ 0 /Yr.
   d. Total Costs $ -38 /Yr.
   e. 10% Discount Factor $ 9.524
   f. Discounted Recurring Cost (d x e) $ -361
3. Recurring Energy Benefit/Costs:
   a. Type of Fuel: Fuel oil
      (1) Annual Energy Decrease (+)/Increase(-) 0 MBTU
      (2) Cost per MBTU $ [illegible] /MBTU
      (3) Annual Dollar Decrease/Increase ((1)x(2)) $ [illegible] /Yr.
      (4) Differential Escalation Rate ([illegible] %)Factor [illegible]
      (5) Discounted Dollar Decrease/Increase(3)x(4) $ 0
   b. Type of Fuel: Electricity
      (1) Annual Energy Increase (+)/Increase (-) 43 MBTU
      (2) Cost per MBTU $ [illegible] /MBTU
      (3) Annual Dollar Decrease/Increase ((1)X(2)) $ 132 /Yr.
      (4) Differential Escalation Rate ([illegible] %) Factor 18.049
      (5) Discounted Dollar Decrease/Increase ((3)x(4)) $ 2,382
   c. Type of Fuel: ____
      (1) Annual Energy Decrease (+)/Increase (-) ____ MBTU
      (2) Cost per MBTU $ ____ /MBTU
      (3) Annual Dollar Decrease/Increase ((1)x(2)) $ ____ /Yr.
      (4) Differential Escalation Rate (__%) Factor ____
      (5) Discounted Dollar Decrease/Increase ((3)x(4)) $ ____
   d. Type of Fuel: ____
      (1) Annual Energy Decrease (+)/Increase (-) ____ MBTU
      (2) Cost per MBTU $ ____ /MBTU
      (3) Annual Dollar Decrease/Increase ((1)x(2)) $ ____ /Yr.
      (4) Differential Escalation Rate (__%)Factor ____
      (5) Discounted Dollar Decrease/Increase ((3)x(4)) $ ____
   e. Discounted Energy Benefits (3a(5)+3b(5)+3c(5)+3d(5)) $ 2,382
4. Total Benefits (Sum 2f+3e) $ 2,021
5. Discounted Benefit/Cost Ratio (Line 4÷Line 1d) 1.0
6. Total Annual Energy Savings (3a(1)+3b(1)+3c(1)+3d(1)) 43 MBtu
7. E/C Ratio (Line 6 ÷ Line 1a/1000) 24.1
8. Annual $ Savings (2d+3a(3)+3b(3)+3c(3)+3d(3)) $ 93
9. Pay-back Period ((Line 1a - Salvage)÷Line 8) 19.2
10. Life-Cycle Cost (Line 1d - 2f - 3e) [illegible]